M.D. VERNON • A FURTHER STUDY OF

VISUAL PERCEPTION

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BY
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CHAPTER I

INTRODUCTION

In 1937 was published a book by the present author entitled *Visual Perception*, the principal aim of which was to collect and collate systematically the main psychological experiments on that subject, their results and conclusions. A considerable part of the book was occupied by the work of the Gestalt psychologists. And although little or no exposition of the *Gestalt Theorie* was included, yet the outlook and the ingenious and extensive experimental material emanating from this school of psychology inevitably dominated the book, just as at that time it dominated the minds of those psychologists who were interested in the experimental approach to perceptual problems. Since then, the main trends of thought on these problems have changed their direction. The Gestalt psychologists, and especially Köhler, have turned increasingly to theoretical speculation as to the physical basis in the cerebral cortex of the perceptual processes. On the other hand, continued study by other psychologists inspired by the original work of the Gestalt school—for instance, on the 'constancies'—seems to have produced a mass of detailed results leading to conflicting conclusions, or to no conclusions at all. The apparently clear outlines originally drawn by the Gestalt psychologists have become blurred and dimmed. And it has seemed perhaps that their experimental results and their theories did not after all indicate a fundamental basis for the understanding of the nature of perception, but rather a one-sided exaggeration of certain features by no means the most important in perceiving as we ordinarily experience it.

Thus it seemed that the time had come for a re-assessment of the material of the author's earlier book (now out of print) in the light of more recent thought and of the mass of new experimental data. Not that the older material must all be discarded—much of it is still relevant and valuable. This is included in the present book and compared with data from more recent experiments. Some of the work of early psychologists and physiologists has, however, been omitted, since it has been dealt with admirably elsewhere by Boring (1942).

But in addition the author has within the last few years reached the conclusion that it is desirable to state, at least in very general terms, certain propositions as to the fundamental nature of the perceptual processes. These propositions are perhaps too general to form a basis for predictive hypotheses leading to possible experimental investigation, and are in that respect less valuable than were the theories and hypotheses of the Gestalt psychologists. Nevertheless, these propositions have the advantage of being more inclusive and therefore less likely to produce a biased polemic such as disfigured so much Gestalt literature. They do moreover emphasize what appears to be the most fundamental quality of the perceived field—its extraordinary unlikeness, so commonly overlooked in everyday life, to the stimulus field.

Bartlett in his paper on 'Perceiving' (1916) and in his book *Remembering* (1932) was perhaps the first psychologist to demonstrate the amount of original construction which goes on in the ordinary process of perceiving. The sensory impulses which arise from the stimulation of the sense organs and peripheral nervous system are but the raw material—indeed only a part of the raw material—from which the final percepts are constructed. The experimental study of perceiving should be aimed at demonstrating how this construction is built up, and how it varies systematically from situation to situation. As will be expounded in the next chapter of this book, it is the author's belief and contention that the individual constructs his perceived world as far as possible in accordance with the maintenance of the maximum of stability, endurance, and consistency. 'With Whom is no variableness' is an ideal attribute which man has applied to the Almighty; but at the same time he strives to overlook much of the 'variableness' in the physical world; and, further, to systematize his knowledge of such 'variableness' along the lines of greatest invariability. The attempt to achieve this, and at the same time to maintain an extreme sensitivity and the power of immediate response to all significant variation in the external world, seems to constitute the ruling principle of our perceptual construction.

But man himself is variable, in spite of the limitations imposed upon himself by social considerations. Bartlett has also demonstrated how greatly perception of the simplest material can differ from one person to another. Thus our experimental study of the main outlines of the perceptual constructive processes immediately encounters the intervention of individual peculiarities which we have no right to ignore—which must, indeed, be recognized to be inherent in those constructive processes in any particular individual.

The experimental work of recent years, and especially that inspired by Gestalt psychology, has indicated some of the common ways in which we codify and react systematically to the varying physical stimuli which impinge upon our sense organs. The study of individual differences in these processes has never been satisfactorily handled, because of its extreme complexity. Indeed, psychologists are only beginning to look for methods of experimental approach. Again, it has rarely been recognized that different individuals can and frequently do produce ultimately the same overt response to a particular situation, but make use of quite different ways of achieving that response. Presumably this lack of recognition is due to the fact that society is interested in conformity of overt response, but is unaware of the way in which it is achieved.

We shall, then, attempt to show in this book how the results and conclusions obtained from experimental work on perception can be regarded as elucidating the constant endeavour of the individual to combine a sensitive awareness of the important variations in his environment with a disregard of all minor variations, especially if these should affect the impression of a stable external world, and of his own consistent relationship to it. The visual apparatus itself gives considerable assistance to this procedure, but we shall not deal with it here. As to how the particular individual handles these problems in his own peculiar way, we can give no more than the vaguest hints.

After a chapter presenting a fuller statement of what appears to be the fundamental nature of perception, and an outline of its development in children, an attempt is made to analyse the phenomenology of particular perceptual processes in various situations. Since the apprehension of 'form' or 'shape' appears to be fundamental in importance in perceiving the external world, this is studied in detail, and from various points of view, in Chapter IV. But the perceived environment is also related to the perceiver as its centre; and Chapter V, on 'Spatial Perception', describes data which bear on this subject. The attempted unification of the constant variations in sensory impressions of the external world appears particularly clearly in the phenomena known as the 'constancies'. For convenience, these are considered together in the same chapter, VI, although it is improbable that the perceptual processes involved are as uniform as Koffka (1935) tried to maintain. A further set of systematic attempts at stabilization appears in the phenomena connected with time errors and central tendencies of judgement, and is studied in Chapter VII.

One of the most vitally important situations which the individual must perceive and understand is that in which there is movement. The movements of his own body in space are considered in Chapter V. But objects in surrounding space also move and change their position, and with it other sensory qualities, and yet retain their essential identity. This is a subject to which all too little attention has been devoted, as can be seen in Chapter VIII, Section (1). Instead, the Gestalt psychologists, and innumerable followers, with that curious emphasis on the unimportant which has so often been the bane of psychology, have spent immense time and labour in studying the apparent movement phenomenon, which has little beyond a rather recondite theoretical significance. However, we have thought it proper to outline this extensive experimental work in Chapter VIII, Sections (2) and (3).

The recent studies of Michotte and the Louvain school have thrown new light on the problem of movement perception. But they have gone much further. They have demonstrated that certain important perceptual phenomena may have their fundamental basis in simple, direct, and immediate impressions which may be independent of any acquired experience. Among these phenomena are included direct impressions of the reality of objects, and of their interrelations in mechanical causality. This work approaches the empiricistic-nativistic controversy by such new and original procedures that we have considered it desirable to describe it in some detail—which is done in Chapter IX.

In Chapter X we discuss those aspects of perceiving which have always been considered to be individual, personal, and subjective—attention, attitudes, perceptual types. In the early days of psychology, these factors tended to be regarded as something supplied by the individual that made the process deviate from its ordinary course; whereas the 'ordinary course' was implied to have, at least in theory, a real independent existence apart from such individual factors. Thus we read studies of 'the effect of attitude, or "set", upon perceiving', as if perceiving could take place without attitudes or 'sets' of some kind. However, psychologists are now beginning to realize that these features form an integral part of the perceptual process; and that a peculiar attitude, a body of personal experience, an individual slant, though overlaid by habit and by social custom, must function in the simple perceptual act, although the experimenter may not recognize it, nor the perceiver be aware of it.

Finally, in Chapter X we examine the possible existence of habitual and inherent modes of perceiving, perceptual 'types', consistently differentiating the perceptions of one individual from another.

CHAPTER II

THE NATURE OF PERCEPTION

If we consider carefully the nature of our perceptual experience of the world around us, we cannot fail to be impressed by the coherence in space and time of that experience; and equally by its extreme diversity. There is a combination and integration of sensations from the different sense organs; a stability and persistence of percepts produced by sensations constantly changing in quality and quantity; and a continuity, both spatial and temporal, of these percepts. Nevertheless, this continuity and stability are not that of a featureless mass, but of an environment consisting of objects clearly demarcated from each other, each possessing its characteristic and recognizable appearance and behaviour.

In our contacts with the external world, certain material objects or certain wave formations of energy impinge upon the various parts of the body surface. In general, these impacts differ in extensity, intensity, duration, and frequency. The sense organs in the sensitive areas respond characteristically, and transmit nerve impulses to the central nervous system which are also differentiated in virtue of their frequency and numerousness; by differences in rate of rise and fall resulting from the sensitivity and adaptation of the sense organ; and by the nerve paths along which they travel and the cortical areas upon which they impinge. Thus it might be concluded that, so far as the receptor areas of the cortex were concerned, the external environment would be supposed to consist of a mass of sight, sound, taste, smell, touch, pain, heat and cold, pressure, joint and muscle sensations, each differentiated more or less accurately in intensity, extensity, localization, and duration; and also in certain qualities such as colour, pitch, etc., which were peculiar to the type of sense organ stimulated. Clearly then there has been a very considerable transformation in the nature of the impressions as they pass from the sense organs to the receptor areas of the cortex. The nature of the environment which they would appear to indicate is utterly different from that which we in fact experience. We know that we receive stimuli from the external world which vary continually in intensity, extensity, and duration. Perceptual experience tells us that it is an orderly and continuous arrangement of solid and stable objects which do not change very greatly from one moment to another; or change only in certain known and predictable ways. Moreover, these objects in the environment are characterized, as Ames (1946a) has pointed out, by their differentiation from one another—by the 'togetherness' of their parts and localization, and by their 'separateness' from one another. It is only in so far as we can differentiate such specific 'wholes' from the total 'whole' and from other specific 'wholes' that we can perceive at all.

It may be generally stated that perceptual reconstruction of the external environment always appears to aim at preserving the continuity and stability of objects in the field. Moreover, it seems that continuity of sensory experience is essential even for the correct interpretation of that experience in terms of objects perceived. Ames (1946b) claims to show by means of various ingenious experiments that when a single sensory pattern is registered at a single point in time and space, there is no definite relationship between this and what is actually perceived. It is only when there is some definite continuity and correspondence between successive sensory patterns obtained from the same spatial points at successive moments of time that a more or less exact idea of the nature of the external world can be obtained. Very often, as we shall see below, there is a correspondence between patterns registered in different sensory modalities, which confirms and enhances the experience. 'Illusions' are apt to result if this correspondence does not obtain. Finally, the impressions are checked by finding whether the sensory patterns suggest a definite function for the object perceived, and whether, when the observer reacts in the light of this suggestion, his actions achieve success.

But it is important also to the individual that he should be aware of such changes in the field as it is essential for his safety and well-being to notice. Thus he must come to realize and differentiate between (1) those changes which are unimportant and can be ignored; (2) those changes which are habitual, recognizable, and easily predictable (that is to say, they come within the range of his previous experience and therefore he is ready to expect their recurrence and knows how to react to them successfully); and (3) those changes that are wholly unforeseen, and therefore must be observed and examined in order that their 'meaning' and significance may be understood—in other words, that they may be related to those changes which are already known and understood.

Clearly then it is of immense importance to the individual to have a reliable method of differentiating the objects and events which do or do not vary from time to time; and, in the case of the latter, of the manner in which they may be expected to vary. It might be supposed that variation in sensory qualities would play a large part in determining such a method of differentiation. And up to a point it is true that certain excessive accentuations of sensory quality are immediately noticed and recognized—unusually bright light, loud sound, intense smell, taste, touch, and so on—and of course almost any degree of pain. But it must be noted again that these sensory variations tend to bring the experiences into category (3) above, of unusual change—that which is unlike familiar change. It is the criterion of function and utility which is the important one in differentiating change, as in identifying objects. Can we successfully react to these objects and events in the usual way, or must we devise some new and more appropriate method?

Now there is certain evidence to show that to the infant there is little differentiation between sensory experiences, little or no perception of objects as such. In an impressive series of researches and observations carried out during the last ten or fifteen years, Piaget (1936, 1937, 1945, 1946, 1948) has traced out the gradual development of perception in the infant from the stage of crude, undifferentiated, and 'meaningless' sensation to that of perception of the world of solid stable objects, retaining their identity over long periods of time and during changes of position and even of physical state. It seems that, during the first three months of life, there is little if any connection in the mind of the infant between sensations of different modes. Each set of visual, auditory, tactile, or gustatory sensations impinges separately on his consciousness and forms schematic patterns associated with the movements of the eyes, the head, the mouth, the hands, involved in trying to perceive them. Each of these schemes seems in turn to swallow up the whole of consciousness; and there is as yet no association between them. The earliest association through simultaneity of occurrence appears to be set up at about the third month between schemes of vision and hearing, in relation to the human voice and face. But the real beginning of integration occurs firstly with looking at an object which has touched him, or seizing it and putting it in his mouth; and secondly, with seizing, examining, and sucking objects which have appeared in his visual field. Thereafter begin intentional movements and actions with objects to achieve desired ends, such as pulling a chain to make a distant rattle shake; and the nature and properties of objects are explored in this way, although for some while they are regarded predominantly as extensions or functions of the child's own actions. But gradually the persistent qualities of objects are differentiated and isolated from those aspects which vary with the child's actions. Thus as he moves relatively to an object, or turns it about in his hands, he realizes that its size and shape vary as it takes up different positions in space, yet it remains the same object.[1]

The recently published work of Gesell, Ilg and Bullis (1949), although it deals largely with the behavioural aspects of the infant's perceptions, goes far to corroborate Piaget's findings, and to stress the enormous importance of visual experiences to the child's development. Thus Gesell *et al.* observed that even the prematurely born, the so-called 'foetal', infant showed signs of visual awareness, a faint interest or attention. This in the normal neonate became a fixational response of the whole body to visual stimuli. In the early weeks of life, bright objects and moving objects were those which attracted attention. But between the twelfth and the sixteenth week, the infant not only followed the movements of a dangling ring, but shifted his regard to the hand which held it; and soon developed a kind of 'ocular prehension', a definite study of objects. His hands opened and shut as he looked; and by the twentieth week he began to handle, then to grasp and to mouth, objects presented to him. Touching, handling, and poking then increased in variety and skill. Towards the end of the first year, processes of tactile analysis were evident, with some awareness of inside and outside, top and bottom, hollow and solid.

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[1] At the earlier stage, if an object for which the child has been reaching is covered by a cloth, he will make no attempt to pull away the cloth. It is as though the object had been absorbed by the cloth, and no longer existed. Again, if he is shown his bottle, and the teat is then turned away from him so that he cannot see it, he will not try to turn it round with the teat towards him. But at the stage of realization of the permanency of objects, he will turn it round at once.

Thus by the integration of visual and tactile exploration the child comes to understand that objects in his environment have a continuous and consistent identity, entirely detached from himself, although when they disappear and reappear somewhere else, he may be confused as to this identity. (Moreover, this applies in general only to near objects which can be touched and manipulated; understanding of the nature of distant objects seems to come much later.) Now the argument has recently been advanced by Michotte (1950a) that the appearance of reality and of permanence in solid objects does not have to be acquired piecemeal through experience in manipulation. It seems that there may exist a tendency to perceive certain organizations of sensory data as immediate and direct impressions of volume and substance, permanence and reality. We shall discuss the evidence for the existence of these impressions in Chapter IX. It seems possible that the child does not have to learn that certain spatial and temporal stimulus patterns indicate permanence and reality; but that he must learn by experience which stimulus patterns possess these qualities characteristically.

Hebb (1949) has recently argued that the data obtained by Senden (1932) show that the perception of solid objects is acquired slowly and by laborious practice. Senden examined the attempts at visual perception of congenitally blind patients who had been operated on for cataract. If this evidence can be accepted, the processes of identification and of naming of common objects by vision alone are for some time after the operation slow, laborious, inaccurate, and uncertain, particularly with objects exposed in varying spatial positions. The shortest period of time necessary to perceive even a small number of objects correctly is a month from the time of operation. These patients are of course fully aware of the qualities of shape and reality in objects perceived tactually—in other words, the 'idea' of the permanence of objects is familiar to them, and also that of object categories (*q.v.*). But patients have to learn by gradual experience what are the characteristic visual qualities of such objects, and to discriminate constant qualities from those which vary with position, illumination, etc.

Whatever the genesis of the understanding of the permanence of objects, there is little doubt that it is enormously developed through the use of language. The child gains the power to think about the properties of objects, and to predict their behaviour—although understanding does not seem to depend completely on the use of language. But his attitude, if he could express it in words, would be: 'One can do *this* with this object; one can expect *this* result.' The evolution of the processes of differentiation and identification would be impossible unless it were done systematically in accordance with an intelligent method of categorizing experience. It seems clear from the actions, remarks, and questions of the child that he gradually works out such systems for himself, on the basis of his observations and experiments. In particular, he marks the principle of the invariability of objects by giving them definite names. He asks whether certain things will be the same to-morrow or for always; or he asks why certain things are not the same as they were. According to Sully (1903) and Stern (1930), the first questions are always about 'new' and unfamiliar things. Even before he can speak, he appears astonished when things move suddenly, appear in unaccustomed places, or look unusual. Thus Valentine's son, aged seven and a half months, was much puzzled by seeing his father's face covered with shaving soap (Valentine, 1942). Gesell *et al.* (1949) noted the awareness of and reaction to strange objects and people at twenty weeks. Later the child deliberately investigates this strangeness. He makes simple experiments: puts his head under water and pulls it out; examines objects in the mirror (Valentine, 1942); drops, throws, rolls objects, floats them on water (Piaget, 1937), in the endeavour to find out what happens to them.

But naming does not always immediately and finally settle the identity of objects in the child's mind. Thus Piaget (1945) noted that words might be associated with particular activities of people: 'panana' meant 'grandpère', and also what 'grandpère' would give him; 'tch tch' was anything that appeared and disappeared past the window, as well as his father playing hide-and-seek. Lewis's son used the word 'bow-ee' for barking dogs, and also for aeroplanes, but not for dogs which did not bark (1936). Or the word may be given too narrow a meaning, and assigned to a person in one situation only, as the following example shows (Piaget, 1937, p. 59):

> Lucienne, à 1:3, est au jardin avec sa maman. J'arrive ensuite; elle me voit venir, me sourit, me reconnâit donc manifestement (je suis à 1 m. 50 environ). Sa maman lui demande alors: 'Où est papa?': chose curieuse, Lucienne se tourne immédiatement vers la fenêtre de mon bureau, où elle a l'habitude de me voir, et désigne cette direction. Un instant après, nous refaisons l'expérience: elle vient de me voir à 1 metre d'elle, et quand sa maman prononce mon nom, Lucienne se tourne à nouveau du côté de mon bureau.

Evidently, he was 'papa' only when he was sitting in his 'bureau'!

Piaget frequently comments on this tendency to link identity with particular spatial position. Gesell *et al.* (1949) also noted manifestations of this tendency. Thus the child of eighteen months liked to have things in their proper places. Even at three years there may be an association of identity and locality. Thus a child may be bewildered if, for instance, he meets his school teacher in the town, away from the school where she belongs.

But if the child were obliged to ascertain piecemeal the characteristic appearance and behaviour of every object in every possible position, his task would be so immense as to become intolerable. Moreover, it is clear from his remarks and questions, and from the examples given, that he links together events of similar kinds. And from these similarities he generalizes certain characteristics common to whole classes of objects and events. At first, these generalizations may appear to us to be quite inaccurate, since they are determined in the egocentric pattern of the child's personal desires, activities, and experiences. But through contact and exchange with adults, who constantly correct, or fail to respond to, his incorrect terminology, he gradually learns the socially accepted forms of generalization. Thus are established the categories we call 'concepts' and 'schemata', which, according to K. Bühler (1930), are fundamental to the formation of 'invariants' in the perceived situation. Now by 'concepts' we mean ideas relating to general classes of objects (not as a rule purely abstract ideas). Thus the concept of a 'dog' does not exactly resemble any particular dog which we have known; but it includes sufficient of the characteristic appearance and behaviour of dogs in general to enable us to identify a dog when we meet it, and react to it appropriately. As we saw, Lewis's son was only on the way to achieving a correct understanding and use of this concept. Piaget also has noted (1945) that a particular example may come to stand in a privileged position to symbolize a whole class of objects, rather than, as with a true concept, all the examples being equally weighted and assimilated together. Such strongly individualized 'pre-concepts' may occur before true concepts are evolved.

It is true that concepts can be formed from categories of experience other than of objects, such as categories of shape, number, etc. But as Heidbreder has shown (1946), the object concepts are far the most easily formed, by virtue of the primacy of objects in the cognition of the external world.

But it is also found that perceived situations are grouped together, from the earliest period of the child's life, according to a different mode of generalization, which has been termed 'schematic'. The term 'schema' has been used diversely by different authors, as has been demonstrated by Oldfield and Zangwill (1942, 1943). But it appears that on the whole the class of situation grouped within a schema is linked by some general framework which relates in turn to particular and appropriate courses of action. The most typical of schemata seem to be those which relate the position of the body to perceived spatial arrangements of objects in the environment. And these schemata are, as Piaget has shown

(1937), laid down in accordance with the class of reactions which have been found by the child to be appropriate and effective in dealing with the spatial relations of objects to one another, and to his own position in space. It is to such generalized categories of perceived situation that the term 'schema' will be applied in this book.

The fundamental importance of processes of generalization in maintaining the appearance of continuity and stability in the external world has been clearly stated by Humphrey (1944):

> Like every other living organism, the human being may be envisaged as struggling to preserve an identity of organic pattern in a chaotic world. In order that this process of self-preservation may be advantageously effected, the organism must be such that it discerns, in a measure gradually increasing as evolution advances, similarities existent under the superficial variations in its environment. Only by such discernment of similarities can the organism survive; without it organic response must be chaotic in a chaotic-seeming world. The ability to discern similarities hidden beneath divergence is the ability to generalize. . . Such ability has reached its climax in the human species.

It seems probable that the perception of stability or variation in phenomena is important in defining and delimiting all concepts and schemata. The possible and permissible variations of appearance and behaviour are always taken into account, since they define the boundary between one concept or schema and another. Thus in our ordinary everyday experience we note particularly a significant variation which may make it difficult to fit the percept to a particular conceptual or schematic category. Other minor variations from the accepted appearance or mode of behaviour of the object are, for all practical purposes, ignored, because they do not interfere with the identification of the object, or the suitable habitual response to it. Increase in accuracy of perception of detail is carried out only by increasing refinement of the categories, and hence a narrowing of the limits of permissible variation from the 'standard form' which determines that category.

Thus we may postulate that every act of perception consists of the extremely exact registration, in the receptor areas of the cortex, of even the minutest qualities and variations in the sensory patterns conveyed to them; followed by a combination and integration of certain of these qualities resulting in a new construction—a percept which is not isolated, but exists as a part of a systematic categorization of experience in concepts and schemata. The particular concepts and schemata involved vary of course according to the particular experience, and to certain innate abilities and qualities, of the individual. Nevertheless, there appear to be certain tendencies common at least to large numbers of people, which determine, first, the content of the concepts and schemata, and, secondly, the general manner in which they are formed. As to the latter, we have put forward what appears to us to be perhaps the most important feature, that of consistency and familiar variation. Other aspects will be discussed in this book. For the moment, something must be said here very briefly as to the *content* of the concepts and schemata.

The contents of any particular concept or schema seem to arise in the young child from those aspects of appearance (visual, auditory, tactile, etc.) to which he most readily responds and reacts. Among these are experiences connected with feeding (both with the breast and the bottle), with the mother's care and the behaviour of other familiar persons, and with moving objects, especially those upon which he can himself act. The relationships of movement, self-activity (as in people and animals), spatial position and causality are very important, and have been investigated in detail by Piaget (1937, 1946, 1948), and are discussed in Chapters V, VI, VIII, and IX below. The functional aspect of experience comes into prominence as the child develops his ability to use things, for instance, his playthings; and to understand their use by others. Thus Valentine (1942) reports that his daughter, aged two years, was constantly asking 'What this for?' And he also gives interesting examples of the importance of use and function in the replies of a child of five years when asked 'What is . . . ?'

> 'What is a rose?' 'Something to make the house pretty.' 'A hen?' 'Something that lays eggs for you.' 'A dog?' 'That's a hard one. It walks on four paws; it barks too.' 'A cow?' 'Something that makes butter and milk for you.' 'A rat?' 'A nasty little creature.' 'A mouse?' 'A nasty creepy crawly thing. A rat and a mouse sometimes bite you.'

It seems that all these various characteristics are linked together in forming the concepts and schemata by which objects are identified as such. But another important category of experience arises in connection with shape as such, and with spatial groupings designated *Gestalten* or configurations. The visual field never appears as an undifferentiated pattern of light, shade, and colour. It is broken up into discrete entities or shapes; these whenever possible become categorized as objects, but when this proves impossible, they are classified in terms of their shape or form. The shape appears to be clearly defined and delimited by its contour; so much so that we both reproduce and recognize the shape by means of its outline. There is little doubt that tactile impressions of contour are closely integrated in this experience. Furthermore, shape has its characteristic three-dimensional aspect which we recognize as 'solidity'. Although solidity is one of the most obvious qualities of most objects, it does not characterize objects only. Michotte (1948) has pointed out and demonstrated that three-dimensionality can be distinguished phenomenally from the 'reality' of objects. Again, tactile and kinaesthetic sensations are normally closely integrated within the perception of solidity.

The arrangement, differentiation, and categorization of shapes into 'configurations' have been the subject of the extensive researches of the Gestalt psychologists. This work will be described in Chapter IV.

Among the most important schemata directing our experience are those connected with the spatial co-ordinates of the environment, and with the individual's orientation to them. These develop as the child learns to walk and move about in space. Head (1920) was the first to postulate the existence and recognize the importance of postural schemata. But not only can the individual orientate himself accurately in gravitational space. He is also continuously aware of his relationship to objects in the three-dimensional spatial continuum, and of objects to one another within that continuum. Furthermore, he relates to the continuum not only the static positions, but also the direction and speed of movement, of himself and of external objects. Thus orientation is maintained in spite of constant change of position.

It has already been noted that as the child's language faculties are developed, his concepts will become increasingly socialized, that is to say, increasingly similar to those of his social group (see, for instance, Sherif, 1948). Many schemata also become socialized, because the child becomes more clearly aware of the behaviour of his social group and conforms to it more closely. Thus in perceiving any event, he as a rule knows 'what to do about it', because it can be fitted to some schema of appropriate behaviour in response to a similar class of events, the schema having been acquired through learning and imitation. The characteristic schemata of the social group may be supposed to be determined, over a long run of years, by what is biologically useful to the individual in the group, or to the group as a whole. They may thus contain enormous accretions from traditional attitudes and behaviour, which often appear to outweigh their genuine biological utility. But there is some evidence to show that events of sufficient potential danger to the individual may set into action deeply rooted schemata which fall outside the social pattern. Panic behaviour in response to sudden and catastrophic danger affords an instance in ordinary life. Even in a laboratory setting, a sudden and unexpected stimulus appearing or moving in the periphery of the visual field may produce a start and an immediate rotation of the eyes until they can fixate and examine the stimulus object. But in general the objects, events, and situations to which we most readily respond are those with which we are familiar. Categories of concept and schemata are waiting to which events may be fitted, and the appropriate responses can then be made easily and quickly. If an object or event does not exactly repeat or resemble one which has been previously experienced, then it may be perceived in a form resembling as nearly as possible some familiar object or event, in order that the appropriate response pattern may be activated. Hence so many of the apparent inaccuracies and transformations encountered in perception, which have formed the material of so many laboratory studies. These we shall discuss in more detail later, remembering that they are in general in accordance with that principle of stability and continuity which we have already formulated.

One further important consequence may be mentioned which seems to result from the tendency to perceive the environment as being as stable and consistent as possible. It is almost universally assumed that what we perceive is really 'there'; that what is 'there' is persistent and invariable, whoever perceives it; and that therefore we must all, *ipso facto*, perceive exactly the same at any one moment of time and in any one part of space. The only differences between the perceptions of different people for which we normally allow are those ascribed to differences of 'attention'. Thus when different people give different accounts of the same incident or situation, they are said to have been 'attending' to different things. Now we shall discuss the problem of attention in Chapter x. Here it may be noted that in general adults of the same type of education and culture, and with so-called 'normal' mentality, do tend in most circumstances to perceive much the same things, because their perceptions are determined to the same extent by similar schemata. Minor individual variations may arise when perception is complex and rapid—as for instance in viewing a motor accident. But the perceptual contents are the same in kind. It has been found, however, that people of different cultures, whose schemata are very different from those of Western Europeans,[1] do often perceive quite differently from us. And children and the insane, whose perceptions are less fully determined by socially integrated schemata, may actually perceive something different in kind from that perceived by the normal European adult. Yet this fact and its consequences are seldom recognized or even envisaged, probably for the reasons given above—namely, that our comfortable conviction of stability and consistency leads us to assume that everyone sees what is really 'there', and that what is 'there' is invariable.

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[1] These schematic differences frequently appear in characteristic differences of language structure. Thus Lee (1947), analysing Malinowsky's studies of the language and behaviour of the Trobriand Islanders, points out that their language contains very few relational terms. The Trobriander rarely compares activities or situations and does not express causal and teleological relations between them. This appears to indicate that, whether or not he is aware of such relations, he recognizes little of the schematic importance given to them in Western civilized cultures.

CHAPTER III

THE PERCEPTUAL PROCESS

(1) THE CONDITIONS OF INVESTIGATION

It is now valuable to consider more closely the details of the process by which, when the sensory impressions have reached the receptor areas of the cortex, a fully developed percept is attained. The process cannot of course be studied objectively, as the passage of the sensory nerve impulses to the cortex has been studied by Adrian (1928). Its details can be observed only by introspection, and are therefore subject to the inevitable deficiencies of introspection. Indeed, so rapid and uninterrupted is the perceptual process in ordinary everyday experience that it may appear to be a unitary and unanalysable whole. Yet, as Michotte (1926) has pointed out, this analysis can be facilitated objectively, by various methods of simplification and modification of the perceptual stimulus, or by shortening the time of exposure, as is done in using a tachistoscope. In this manner, the process can be arrested at some stage of incompletion. Alternatively the completion of the process can be retarded by making perception difficult: the stimulus field may be complex, ambiguous, unclear, or dimly illuminated. In all these cases it is necessary to instruct the observer to direct his observation to the gradual development of the percept, or to some particular stage of it. But it is important to remember that we are not justified in concluding that the process thus analysed, interrupted, or retarded, is identical with the process which would have occurred under ordinary conditions. In particular, the direction of the observer's awareness to some particular part of the process may give it an altogether artificial prominence and importance. We cannot even be sure that certain secondary attendant processes, such as imaging, may not in some cases be actually aroused by instructions to observe their occurrence. All that we can hope to do is to point to some of the phenomena which occur most frequently, if not universally, under these conditions; and to decide with greater or less assurance if they are normal and essential constituents of the perceptual process.

(2) THE FUNDAMENTAL STAGES IN THE PROCESS OF PERCEIVING

Although a number of different experimental methods and different types of experimental material have been employed by the various workers upon this problem, there seems to be a fair amount of agreement between the latter as to the fundamental stages which may be observed in the development of full apprehension and knowledge of the nature of the objects exposed. The first of these stages seems to consist of a *vague awareness* or knowledge that there is something in the visual field. Davies (1905), exposing a series of large simple geometrical forms by means of a short flash of light in a dark room, found that there was a primary consciousness of light occurring before any consciousness of form. Helson and Fehrer (1932) also found that when simple geometrical forms of very low brightness were exposed, the observer was aware of the appearance of light at a much lower intensity than was necessary for the appearance of form. This awareness of light is, however, followed immediately, if not superseded, by the vague impression of an indefinite object in the field. This was the first stage obtained by the observers of Galli (1931) and of Zigler, Cook, Miller and Wimple (1930), as simple geometrical forms were moved gradually inwards from the periphery to the centre of the visual field. The first stage found by Dickinson (1926) in the tachistoscopic perception of groups of letters and of playing cards was the experience of a visual pattern having 'thereness' or flat clearness without any logical meaning. This seems to indicate a rather more fully developed state of the percept; as does also Freeman's report (1929) that during the first stage of the perception of meaningless ink-blots the general extent and position of the form was determined and qualified—whether it was near or far, to the left or to the right. Throughout these descriptions of the first stage, however, runs the note of vagueness and uncertainty; this has been characterized by Bartlett (1916) as 'having a feeling of' or 'an impression of' something.

As the awareness of the existence of the object in the visual field becomes more certain, we pass on to the next stage, which has been called by Dickinson (1926) and Freeman (1929) the stage of the *generic object*—the awareness that the visual stimulation is connected with some kind of object with an existence in the visual field. Moreover, this object falls into some general category of objects, or bears a similarity to some known class of object (Galli, 1931). This knowledge usually results from a partial differentiation of the total visual field, whereby certain parts stand out more clearly, and assume more importance than their surroundings (Dickinson, 1926); certain details may be noted as significant in the interpretation of the perceptual situation (Freeman, 1929). Thus at this stage the grouping or organization of the field begins (Gemelli, 1928a). As this organization becomes more and more detailed and complete, the relevant and important parts rise out of the field, the rest of which fades into the background (Freeman, 1929). These parts, and especially their more important details, take on specific characteristics. That is to say, they are recognized as appertaining to some particular and specific object; and this stage is called the stage of the *specific object*. The form characteristics of the field, or rather, of the relevant and important parts of it, are now fully recognized; the conscious reception of the pattern of visual stimulation is complete.

This part of the development of the perceptual process was described somewhat differently by the observers in an experiment by Douglas (1947). She exposed complex pictures for 1/400th second. These at first were out of focus, but were gradually brought into focus at successive exposures. Possibly as the result of this gradually increasing clearness of the stimulus, at the first stage of perception the figures were described by the observers mainly in terms of sensory characteristics such as haziness, intensity, size, etc. Sometimes geometric figures were suggested during this stage, but they disappeared as meaningful forms were recognized. At the second stage there was much exploration, attempts to 'match' the shapes

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by analogy, and trial of a succession of forms in order to find the appropriate one.

In certain cases, perception may go no further than this stage. It is reported that in cases of visual agnosia resulting from brain injury, shape is perceived as such, but the patient is unable to take the next step and to identify the object. Russell Brain has given a clear description of such a case (1941a), and Zangwill indicates that such a disability is characteristically associated with disorders of the left parieto-occipital cortex, near to the 'speech centre' (1948). This is interesting in view of the importance of naming in perception, which is discussed below. With injuries predominantly of the occipital cortex, the perception of shape and contour may be abnormally slow, as Teuber and Bender have found (1949), but there is no essential difficulty in identifying objects once their shape has been perceived. But in the cases described by Senden (1932) of congenitally blind patients who had been operated on for cataract, both visual perception of shape and also the further stage of identification of objects developed only very gradually.

It seems that the afore-mentioned stages of perception are features of perception generally, and not only of visual perception. Zigler and Northrup (1926) found that in tactile perception of common shapes, salient features of the outline, such as acute angles, first of all stood out so that their shape was recognized as such; and that then a general impression of the whole profile of the object was gained, but still without identification (this could only take place after the tactile impressions had been converted into visual images of the shape of the object). Usnadze (1927) again reported three stages in the tactile perception of objects: (1) identification of sensory qualities; (2) identification of form qualities; (3) meaning awareness of the specific totality of form qualities.

The last essential stage of the perceptual process then is that of *identification* and *understanding of meaning*. The visual pattern takes on the meaning of a form or object in the external world. The essential nature of this stage is clearly shown in the introspections of the observers in Bartlett's experiments on perception (1916); they experienced an 'effort after meaning', a conative drive towards the completion of the perceptual process by the attribution of meaning. Even for the child and the unsophisticated adult the understanding of meaning is in itself a process of enormous complexity and extreme difficulty of analysis. Such an analysis is at present impossible by the methods of experimental psychology. We shall discuss subsequently certain experimental observations which appear to bear upon the understanding of the meaning of words. Here it is sufficient to indicate that understanding usually includes an element of familiarity—as Freeman (1929) expresses it, the feeling: 'I know what you are'; the awareness of having met before with some comparable object or situation. And this in turn implies a tendency to the correct response or reaction; the meaning, when fully understood, includes the knowledge of how to deal with this particular perceptual situation. In the case of real objects the primary unitary meaning consciousness breaks down into categories of experience such as: 'What is the use of it?' or 'What is it made of?' When the meaning is not fully understood, an effort to obtain further perceptual information is usually suggested. Hence we are justified in making our original statement, that the perceptual process when complete includes some form of response tendency. Recently Piaget has found that, for young children of two to three years, identification and recognition of shape may not occur without an overt and active response. Thus the child may be able to discriminate shapes which he can handle or cut out, or even when he merely makes the movements of cutting out, before he is able to discriminate them by merely looking at them.

Both Bartlett (1916) and Gemelli (1928a) comment on the frequency of *naming* in perception. Indeed, Gemelli gives it as the fourth and final stage of perceiving. Bartlett does not seem to have found that naming occurred in every case; it was most frequent with the more elaborate figures. Possibly with certain of the so-called meaningless material—arrangements of lines, geometrical figures, etc.—no simple name could be given to the figure as a whole. Instead, it was often described verbally. It seems fairly clear that during the development of perception in children, naming is fundamental. By naming, the child establishes for himself the stability and continuity of a particular object, and also relates it to the conceptual category to which it belongs. In the adult, the 'effort after meaning' and the tendency to response are both satisfied very often by the overt response of naming. The giving of a name to an object establishes its meaning, and its relationships and resemblance to the background of experience. It is pigeonholed into the appropriate category which determines the awareness of its nature, construction, and function, and it may be then kept there ready for future reference. Indeed, it has been suggested that naming and verbal description affect the actual nature of the perception. For instance, McGranahan (1936, p. 202) states that: 'The effect of language on perception appears to be to make those features of the objective world that are represented by linguistic forms stand out in greater articulation, to cause similarities to be seen in things similarly represented and in general to influence perception in the direction of the speech forms.' We have no actual experimental evidence of the fact that we tend to perceive most readily that which we can name most easily—although the results of Bartlett (1916) and, later, of Hall (1950, see p. 229) suggest that it may be so. And experiments by Gibson (1929) and by Carmichael, Hogen and Walter (1932) show that the influence of naming is strong in the reproduction from memory of visually perceived forms. If very short periods of exposure are given, the perceptual process can sometimes be completely arrested at one of its intermediate stages. Thus with exposures of geometrical figures for 1/100th second (10 σ), Brigden (1933) found that the perception might reach only the generic object stage, with a gross differentiation of general outline and shape and no attempt at seeing detail. After that, an increase of time of exposure up to from one-fifth to two seconds actually decreased the accuracy of perception, for there was usually an unsuccessful attempt to perceive further detail in order to develop the specific object, with the result that even the broad outlines of the generic object were forgotten. But Fehrer (1935) found that the number of exposures necessary for perception of line figures of varying complexity decreased steadily as the time of exposure increased from 40 σ to 680 σ. Carl (1933) states that with simple pictorial material the generalized cognitive act may be completed with an exposure as short as 27 σ. Zeitler (1900) obtained tolerably complete perception of letters and short easy words in an exposure of 10 σ. But Dodge (1907) points out that such types of perception are scarcely comparable to normal perception. If the pre- and post-exposure fields are dark, and the illumination of the exposed field sufficiently strong, perception of a sort can take place in a fraction of 1 σ, as for instance during the period of illumination given by an electric spark. But it seems probable that only fragments of the field are really perceived, and that these become spontaneously developed and elaborated in the primary memory image, which may be unusually vivid and persistent under such conditions, and can therefore be reviewed over a considerable period of time. Thus certain outstanding features of the objective field may become unduly emphasized; this was what led Zeitler (1901) to conclude that reading took place from the 'dominating' letters of words, since these were the parts which stood out sufficiently to be perceived during his very short exposure. But Dodge (1907) considers that, for a normal type of perception, a longer exposure is necessary to allow time for the functioning of the 'clearing-up process', during which the effect of previous stimulation (i.e. by the pre-exposure field) wears off, and the new sensory and perceptual process develops. An impression is said to be fully 'cleared up' when it can be differentiated from its predecessor; that is, in tachistoscopic perception, when it has developed to the stage of awareness of meaning. Under favourable conditions, this is not less than 100 σ. But to obtain a lasting impression of a complex figure, a considerably longer period is necessary. Thus Gagne (1944) found that in training for aircraft recognition, it was better to give one second exposures of slides of aircraft than one-tenth or one-fiftieth second exposures.

The spontaneous development of incompletely perceived impressions may occur also in peripheral vision, if the objects are never brought in near enough to the centre of vision for accurate perception. Thus Drury (1933) exposed simple line figures at angles of 10 degrees and 20 degrees from the fovea, requiring his observers to reproduce the figures by drawing them. He found that after a large number of exposures the percepts became certain and stabilized, whether or not they coincided with the corresponding stimulus objects. Thus the percept developed fully from the vague and distorted sensory pattern, and the observer became subjectively certain of its form even when this was in point of fact very different from the stimulus form.

(3) THE FUNCTIONS OF IMAGERY

We referred in Chapter II to the integration of sensory patterns of different modes in the formation of completed percepts. It may quite commonly occur that the observer does not receive actual sensory stimulations from all these modes, and yet may be aware, as it were in his 'mind's eye', of the missing sensory impressions. These are conveyed by means of sensory *imagery*. For instance, the perception of fruit may call to mind imagery of its taste and smell before these are perceived sensorily. Again, in playing a ball game, we may be aware of the 'feel' or kinaesthetic imagery of the movements necessary to hit the ball correctly; and this imagery forms an integral part of our perception of the approaching ball.

Thus in complex perceptual situations, before perceiving is fully completed, sensory imagery may commonly occur. In certain cases, it seems essential to the final identification and the full understanding of the meaning of the percept. At one time it was claimed that all perception necessitated the imaging of previous appropriate and related experiences before the object perceived could be finally identified. But it has been found experimentally that imagery is not reported in every act, or even in most acts, of perception; and some observers, even those highly trained in introspection, report it rarely if ever. It seems that although certain individuals may experience imagery frequently in making elaborate and complicated perceptual acts which are studied experimentally, yet it is not essential to complete perceptual understanding, and indeed may, as stated above, be an artefact of the experimental situation.

Visual imagery, except in the form of the primary memory image, is less common in the perception of figures and objects than in the perception of words; and we shall consider it in more detail in connection with the latter. However, Rogers (1917) found that in the perception of ink-blots it was very frequent, although it occurred late in the temporal sequence of the stages of perception. Ink-blot material is unusually prone to set up visual imagery; and indeed any individuals who have carried out the Rorschach, or similar, tests, would have had a habitual tendency to experience such imagery. Other writers have pointed out the frequency of resort to imagery when thought is baffled, and the perceptual object unfamiliar or difficult to recognize. Bartlett (1916) found that very vague visual apprehensions, of the type described as a 'feeling of' or an 'impression of' something, were liable to develop into imaging, particularly when the 'something' was a definite and concrete object or experience. Imaging also increased with the increase in complexity and detail of the material presented. Visual imagery is a frequent, if not an essential, accompaniment to the tactile perception of objects. Zigler and Northrup (1926) and Zigler and Barrett (1927) found that when the salient features of the outlines of objects, such as sharp angles, had been perceived tactually, these impressions were converted into visual images of the shapes. In these, the vague isolated tactile impressions were organized together and incorporated into a total meaningful form, which could finally be named.

Rogers (1917) found that *kinaesthetic* and *organic sensations* were also frequent accompaniments of perception. It seems probable that these accompaniments often occur imaginally, if not sensorially. The kinaesthetic sensations were either of a general, diffuse, bodily type, or were specifically localized, particularly in the eye muscles, and in the muscular processes connected with vocalization. Incipient vocal movements or vocal kinaesthetic imagery would of course occur in connection with the process of naming; and eye movements in the exploration of the perceptual field. Organic sensations were less frequent in occurrence. Rogers states that the function of the kinaesthetic sensations was to interpret the perceptions, and to 'carry self-instructions either to seek meaning or determine the appropriateness of significance'. It seems probable that these general and diffuse kinaesthetic and organic sensations were set up by the incipient muscular responses to the conative drive, aroused by the experimental situation, towards the completion of the perceptual process. If this be so, we should expect them to be more prominent the greater the desire of the observer to apprehend and assimilate accurately and completely the perceptual situation. According to Jacobson (1929), not only perceiving but also imaging is always accompanied by changes in muscular tension, for instance, of the eye muscles; but the sensations of tension are usually ignored unless awareness is specifically directed upon them.

(4) VARIATIONS IN THE PERCEPTUAL PROCESS ACCORDING TO THE PERCEPTUAL SITUATION

It has been pointed out that, whereas the fundamental stages of the awareness of generic and specific object and the understanding of meaning occur in all perceiving, certain other processes such as the use of imagery are found in certain perceptual situations and not in others. It is convenient to consider some of the main classes of perceptual situation, and the variations in perception which are characteristic of these situations.

(*a*) *Perception of Real Objects*. Although the greater part of the perceptions of ordinary everyday life are concerned with real objects, comparatively little controlled experimental work has been devoted to the investigation of this type of situation. In the main, the perception of objects by adults is so rapid and immediate that any analysis of the process is difficult. Thus Moore (1919) found that in the perception of real objects, the observers were not aware of sensations of light, colour, etc., as such, but that the primary state was the awareness of meaning. Moreover, as we shall show below, representational drawings of objects are so readily identified with the objects depicted that experimenters have seldom paid much attention to the great difference of sensory pattern between the two types of situation. But a study of children's perceptions shows that, below a certain age and maturity, this identification is neither as immediate nor as accurate as it is in adults.

It appears that in the perception of real objects, *evaluative* processes may be particularly prominent. Thus Moore found, as we have already mentioned, that the primary and unitary processes of attribution of meaning usually broke down subsequently into categories of experience of which the most important were: (1) 'What is the use of it?' (2) 'What is it made of?' Imagery is not necessary or integral to this experience. Neither, according to Moore, is naming. It seems probable, however, that naming at least at an imaginal level must usually occur before the categories of use and material are finally determined. A further type of evaluation that occurs very frequently in ordinary everyday life takes the form of asking, 'Is it good, or efficient, i.e. does it satisfy the purpose for which it was intended?' 'Will it be useful *to me*?' Aesthetic evaluation may also occur, though more frequently in some observers than in others. The relationship, or indeed the mutual incompatibility, between utilitarian and aesthetic evaluation open up a field of cognition of great interest, but one which lies outside the scope of this book.

(*b*) *Perception of Representations of Real Objects*. This class includes not only drawings and pictures such as are familiar in ordinary everyday life, but also a great deal of the material which has been used in perceptual experiments. This material may be simple and semi-diagrammatic in appearance; but in so far as it is interpreted by the observer as representing a real object, it must be included in this class. Some modern art productions, those of the so-called 'abstract' art, fall not into this category but into the next; while 'sur-realist' pictures may be said to hover uneasily on the borderline, according to the attitude of the observer towards them.

The nature of the process of perceiving this class of material is determined by the accuracy and clearness with which it represents real objects. Where representation is obvious, the observer will pass almost immediately to the stage of understanding of meaning, usually signalled by the naming of the objects represented. The actual pattern of lines, patches of colour, etc., will hardly be considered as such, at least by the normal adult. But when the identification of the objects depicted is not easy, the observer is usually aware of such a pattern before he reaches the final stage of identification. Much imagery of related representations and objects may occur with vague questioning and prolonged, sometimes arduous and unpleasing, 'effort after meaning'. Such processes were found by the author to occur in viewing the Street incomplete pictures (Street, 1931; for examples, see Fig. 1). Kolligs (1942) also found that the tendency to try and find meaning was much stronger with representational than with non-representational material. If the observer cannot easily make out what the pattern represents, he may be left feeling dissatisfied and worried. Douglas (1947), for instance, found that at her second stage in the perception of complex forms there was some evidence of frustration, with rationalization, and criticism of the experimental conditions. There may also be much highly critical evaluation in terms of 'likeness' to real objects. The observer may dismiss the experience contemptuously because the representation is 'quite unlike' a real object. This is particularly characteristic of the reactions of unsophisticated observers to modern art productions. Again, older and more intelligent children, shown pictures somewhat resembling representations of real objects, tended to call them 'bad painting', 'child's drawing', etc. (Vernon, 1940). Once identification has occurred, a further evaluation may take place. The sophisticated art critic will arrive at this stage com-

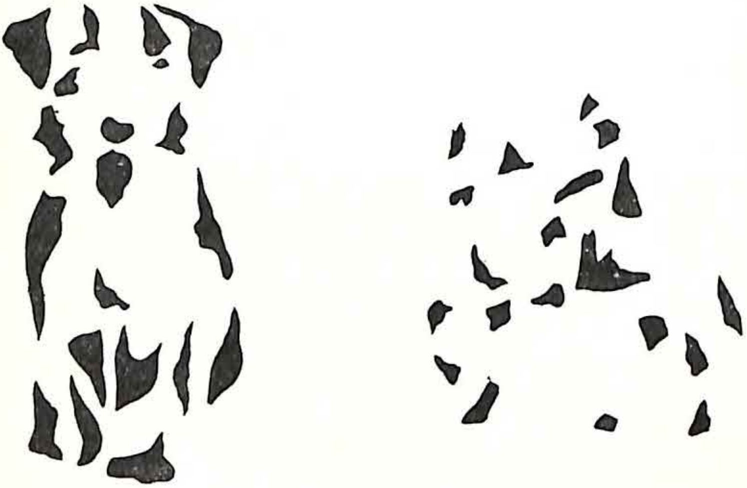

Fig. 1. 'Incomplete' figures.

paratively soon, indeed before complete identification has occurred. But here the representation is reacted to as a pattern rather than as a representation. Utilitarian evaluation is unlikely to occur in these cases.

It has already been pointed out that in certain cases of brain injury the observer is unable to reach the stage of identification in terms of the object represented, and stops short at the stage of perceiving the pattern or shape as such. There seems to be some evidence that young children may also fail to reach the stage of identification in terms of real objects. It has been mentioned that two-year-old children can name simple outline drawings of animals, familiar household objects, etc. Bühler (1930) states that to children under two years of age pictures are just pieces of coloured paper. Later, the child treats these pictures as if they were the objects themselves. But by grasping at and touching them, he realizes that they lack the weight and solidity of real objects. Finally, he realizes their representational character; but this process cannot occur until the child is able to name objects, and hence also their representations. Again, in the Terman-Merrill test (1937), the normal child at various ages is expected to recognize and name the following percentages of simple black and white outline drawings of familiar objects ranging from a boot to the leaf of a tree:

At year 2, 11 per cent
" " 3, 67 " "
" " 4, 90 " " .

Here the drawings of each object are very clear and simple and are presented in isolation. With more complicated coloured representations, and with representations of whole scenes, identification will occur much later. Thus Binet and Simon (1908) found that a child of three merely enumerated the objects shown in a picture; a normal child of seven described these objects; but it was not until fifteen years that he could fully interpret what was happening in the picture, the relationships of the objects and people, etc. This age of interpretation depends largely on the complexity of the picture. The author (1940) found that partial interpretation and understanding of the picture began soon after seven years; and that a normal child of eleven could interpret the picture as a whole. But throughout this latter period, the child was liable to misinterpret the relationships in the picture; to stress unimportant and subsidiary details while omitting to note what might be the key-points to the actions depicted.

It is clear that the interpretation of complex pictures goes far beyond the stage of simple perception. Indeed, the experiments of the author (1940) indicated that it was not till the child had reached a certain stage of emotional maturity that his cognitive and imaginative powers became sufficiently well integrated for him to be able to interpret a picture by supplying explanations in terms of events and actions not actually depicted there. But it is important to take into account the fact that these stages in the development of perception and cognition are gradual. Thus it cannot be assumed that a representation will convey to the child's mind the same meaning, in terms of real objects, as it conveys to the adult's. Moreover, adults vary in their ability to perform this interpretation quickly and accurately. Recent experiments by the author (1947) demonstrated these differences in the tachistoscopic perception of complex pictorial material. Some individuals completely misunderstood the whole meaning of certain pictures. It appeared that the ability to interpret these pictures was related to intelligence test scores. Moreover, interpretation was more difficult in so far as the material was unusual, unexpected, or bizarre in nature.

The ability to interpret pictures meaningfully seems also to be in part a function of cultural factors. In our civilization, children are constantly shown pictures as illustrations of stories, and hence learn in time the relationship between shapes and meaningful concepts and ideas. This does not necessarily occur in other cultures. Thus Nissen, Machover and Kinder (1935) found that African negro children living in French Guinea were more backward on Performance tests such as the Manikin and Feature Profile and Healey 'A', which involve the apprehension of meaning, than on tests such as Cube Imitation and Formboard tests which depend mainly on perception of shape. Nadel (1937) found that with adults of two West

African tribes, one set, the Yoruba, used a meaningful orientated approach to the perception and remembering of pictures. These people possess types of art, drama, and religious system characterized by realistic imagery and rational logical cohesion. The second tribe, the Nupe, have an art which is decorative and ornamental, and their beliefs revolve around abstract impersonal magical principles. Adults from this tribe showed perceptions and memories which were enumerative, stressing spatial and temporal relations rather than meaning or rational consistency.

(*c*) *Perception of Abstract Shapes and Patterns.* In everyday life we are familiar with the abstract patterns of material used for decorative purposes—for fabrics, tessellated pavements, carved furniture, architectural ornaments, etc. It is doubtful if as a rule we perceive very clearly the details of shape in such material, observing rather the general effect of the pattern as a whole. It is somewhat unfortunate that experiments on perception have made such extensive use of abstract patterns and shapes. Originally this was done in accordance with the Ebbinghaus tradition of using 'meaningless' material. It became clear from the work of Bartlett (1916), however, that no perception was really 'meaningless', but that the meaning was expressed in terms of characteristics of shape, rather than of real objects represented. In order presumably to obviate the effects of familiarity and particular experience, the Gestalt psychologists have also made extensive use of such material. It is therefore important to consider carefully the characteristic form taken by the perceptual process when such material is used.

We must study in the first place the perception of very simple elementary forms—the square, the circle, and the triangle. From experimental work on children and animals, it appears that these shapes are so fundamental as to be readily recognizable as shapes at the early stages of development in perceptual ability. Lashley (1938) found that rats were able to discriminate between triangles and squares, and triangles and circles. Having learned to jump towards a triangle rather than towards a square or circle, the rat continued to do so when the triangle was merely outlined or dotted, or was altered in size. But if white figures on black grounds were substituted for black figures on white grounds, there was complete loss of discrimination. Fields (1932) also found that when the triangle was tilted to one side, the rat no longer recognized it. Lashley (1938) considered that the rat responded more readily to differences of orientation, size, and brightness than to shape as such. But the work of Kroh (1927) did suggest that chicks could respond to triangularity as such, by pecking only at food placed on triangular papers. Gellerman (1933) also found that chimpanzees and children of two years could react to triangularity as such. Thus they could choose a triangle from a square, a circle, or even a trapezoid; when the triangle was turned upside down; reversed from black on white to white on black; changed in colour; outlined in white dots (though here the chimpanzees showed greater difficulty in responding). The children could also respond positively to a cross on a variety of shaped backgrounds. But the chimpanzees found this more difficult. They showed a greater tendency than the children to be influenced by the shape of the background, particularly if the latter was triangular. Indeed, the triangle appears to be the most readily recognized of all forms, when presented, for instance, in peripheral vision, with very dim illumination, or for tactile perception.

It seems then that little children may be able to perceive and recognize shape as such, apart from position and orientation, at a very early age; Gesell *et al.* (1949) put it at thirty-two weeks. On the other hand, it appears that the congenitally blind post-operational cases of Senden (1932) had the utmost difficulty in learning to differentiate between simple shapes such as the square, circle, and triangle. Sometimes they were obliged to touch the corners of a triangle before they could distinguish it from a circle. Thus even simple shape perception could be learnt only by gradual experience.

It was also found by Piaget and Inhelder (1948) that analysis and clear awareness of the exact characteristics which constitute the differences between shapes were not developed till much later than the age given by Gesell *et al.* When children were required to draw copies of simple geometrical figures, they could differentiate open from closed forms at three-and-a-half to four years of age, and, soon after, rectilinear from curved figures. The differentiation of the square and the triangle was then gradually evolved, apparently through the formation of concepts of angles, right angles, parallel lines, and so on. Osterreith (1945) found that when children of four years and upwards were asked to copy a complex meaningless figure (see Fig. 2), the drawings of the youngest children were extremely vague, and consisted of a few details dotted about irregularly. At later ages, the children made increasingly exact copies of details, but these were juxtaposed without any idea of the pattern of the whole. It seemed that the child perceived the details separately, without any relation to one another, or to the total structure. It was not till eleven to twelve years of age that he began to draw a structural whole within which the details were integrated. Again, if the children were asked to find and recognize in the main diagram parts drawn and presented separately, the younger ones identified the characteristic and outstanding details with fair ease. Less outstanding details were recognized from the ages of seven to nine years. But again the main outlines of the total structure (for instance, the rectangle with diagonals) were not identified till nine to ten years of age, although to adults these outlines jumped straight to the eye. It seemed that the child as he grew older developed an idea of the general outline structure, and it was this that he perceived and

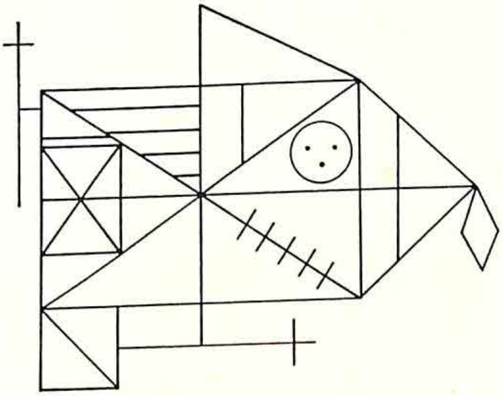

Fig. 2. Complex 'meaningless' figure.

recognized; whereas the younger child saw an undifferentiated mass dominated by a few outstanding details.

It must be noted that the young child cannot analyse out a complex situation verbally and describe it to himself, as does the adult. In the latter, naming and verbal analysis seem usually to occur in the perception and reproduction of all but very simple shapes. Thus Bartlett (1916) reported his observers as saying, for instance, 'a square with its side gone', 'a Z upside down'. Remembering of other than very simple shapes by virtue of form alone is usually inaccurate and unreliable, since the primary memory image fades quickly. But immediate discrimination between two more complex shapes may be possible without verbal analysis, although such analysis is necessary before the observer can decide the exact manner in which the two shapes differ from one another. It appeared from some work by the author (1947) that this power of discrimination varied in different individuals, and was related to their visual sensitivity, as measured by the differential threshold for brightness. This observation seems to tally with Lashley's findings on the importance of brightness differences in the discrimination of rats (1938). It may be therefore that a fundamental ability for simple form perception does exist, and is based on the ability to discriminate differences of brightness in the field (cf. also the observations on contour effects, pp. 43–4). Moreover, certain characteristic arrangements of brightness contrasts—a black triangle, square, or circle on a white ground—are remembered even by children and apes. But more complex form differentiation and memory are largely dependent on verbal analysis and naming. Thus understandably these are considerably improved by practice, even in adults. The author showed, for instance (1947), that they were related to facility in mathematics. This may be a function of some inherent ability for shape perception, or '*k*'-factor; it seems probable that practice effects are also important.

It is doubtful how far evaluation occurs naturally and spontaneously in the perception of abstract shapes and patterns. But aesthetic evaluation is readily aroused, at least in certain individuals, by training in the appreciation of 'good' or 'pleasing' patterns.

Some curious data were obtained by the author (1940) with regard to the perception by children of material which lay on the borderline between the representational and non-representational. There was a strong tendency to see this as representating men or animals. But because the child perceived that the representation was not clear and accurate, he was liable to qualify his responses. Sometimes he gave them semi-human attributes, such as 'ghosts', 'scarecrows', 'black things jumping', etc. Sometimes he called them 'queer', 'funny', 'squiggly'; or 'like . . .', 'sort of . . .'. Only the oldest and most carefully observant of the children gave long and accurate descriptions in terms of the colours and shapes that were shown. It seemed probable that a tendency towards animistic phantasy in the younger children caused them to interpret even abstract material in terms of living creatures and their activities. Only the older and more mature children were capable of objective and non-representational responses; although at an earlier age the children showed evidence of awareness of differences between clearly representational and non-representational material. Thus it seems that the perception of shape as such, other than of very simple shapes, may be a comparatively late and sophisticated stage in development.

(*d*) *Perception of Symbolic Material.* The characteristic of this type of perception is an extension of the perceptual process in its achievement of final meaning. The latter does not reside in the shape as such, nor in its direct representation of an object which has been perceived as such; but in some idea which the perceptual material suggests or symbolizes. Included in this category are geometrical figures, diagrams, and written and printed material. The third type is the one with which we are most familiar; and extensive experimental work has been devoted to the investigation of the processes which take place in its assimilation.

There are two factors of essential importance which must be taken into consideration in studying the *perception of words.* First, all words are primarily speech units; the word as written and read derives directly from the word as spoken, and its origin is always implicit—hence some traces of auditory and vocal processes always occur during reading. Secondly, the perception of the word is not completed by a mere apprehension of its visual and auditory form or structure. Because every word is a symbol, therefore awareness of its meaning necessitates at least some awareness of the idea or experience it connotes. No doubt the earlier stages in the perceptual process occur in much the same way with words as they occur with other visual stimuli. But it should be noted that the observer is even less aware of details of these than he is in perceiving representational material. Indeed, the rapidity of reading is such—several words can be read during a fixation pause of the eyes of 0·3 seconds—that no exact sensory impressions of the full details of the letter shapes can be obtained. At most a general 'word outline' is perceived, and the symbolized meaning of the words obtained immediately, without any awareness in ordinary reading of intermediate stages. But in experiments on reading, introspective evidence always reports the existence of some type of auditory or vocal process which occurs between the stage of the generic object and that of the full awareness of meaning. This process is termed 'inner reading' (Kakise, 1911) or 'inner speech' (Downey, 1927). It may sometimes exist in the form of actual laryngeal movement; or this may be replaced by auditory-kinaesthetic-verbal imagery (Moore, 1915). This auditory image, according to Wiegand (1908), could be reproduced when only vague signs of the word had been seen, and not a single letter actually identified. In his earlier paper, Moore (1915) stated that this imagery preceded the awareness of meaning. Thus the stages occurring in the perception of pictures, etc., were reversed; for these, naming always followed the apprehension of meaning. But in a later paper (1919) he states that the image of the word is preceded and determined by the meaning. Since, however, the meaning of words is primarily associated with their sounds, as heard or spoken, it seems probable that some of the imagery of this type is at least simultaneous with, if not previous to, the awareness of meaning of words.

It is possible that Moore is referring to two different processes, however. It is well known that in the normal reading of continuous prose and poetry, there occurs the process, known as 'inner reading', which is a continuous sub-vocal sounding accompanied by laryngeal and lip movements of the words when they have been fully perceived and understood; and this lags at a more or less constant distance behind the perceptual process. This 'inner reading' is a legacy of the educational method of teaching reading by requiring children to read aloud. Teachers have often tried to suppress 'inner reading', with greater or less success; for it is a drag on ordinary reading and is in no way essential to the comprehension of the reading material. Only in the reading of poetry is it of paramount importance in providing the necessary sense of rhythm. It is entirely dependent on previous perception and comprehension of the material. Hence it must be distinguished from the auditory and vocal processes actually necessary to complete perception. It is true that these processes are very difficult to isolate, since they are neither prominent nor persistent, and occur at a relatively early stage of the perceptual process.

Apart from the primary type of inner speech which is essential to the full understanding of the words read, there may of course be a great deal of secondary imagery connected with the ideas which arise in the course of reading. There has been much controversy as to the amount of this. It seems probable that it varies greatly in amount with the nature of the reading material. If the latter deals with concrete objects and events, imagery relating to these may be experienced. Again, if the material is such that it baffles the rapid understanding of its meaning, there is, according to MacLennan (1902), a constant resort to imagery, just as imagery is often called up in the elucidation of complex pictorial material. Kakise (1911) found that in the perception of easy and familiar words, imagery followed awareness of meaning; in the perception of difficult and unfamiliar words, imagery preceded meaning. There has been considerable dispute as to whether this secondary type of imagery is essential to the understanding of the ideas to be conveyed by the words. Jacobson (1911), Weld (1917), and Schaefer (1928) held that imagery characteristically occurred before full meaning was obtained. Moore (1915) and McDonough (1919) found that meaning could be obtained before the imagery appeared, and was therefore independent of it. It may be that with familiar and abstract words, imagery becomes so rudimentary as frequently to pass unrecognized, although some imaginal process is still essential. What does seem essential to understanding is the realization of the type of meaning designated by Moore (1919) as 'I know what you are'. This then is liable to become elaborated and dissociated into various categories of experience connected with the utility of the object designated, and its relationship to other facts of experience. During these later stages, imagery is often a paramount, possibly an essential, part of the experience. If after the words have been read a long period is allowed for introspection and thought, then there will be time for the development and elaboration of imagery, and observers will tend to report it at some length, and possibly over-stress its importance. On the other hand, rapid reading of easy material which requires little thought for the understanding of its meaning may arouse little imagery. The reader is content to remain at the stage of 'I know what you are' without proceeding further.

We have dealt at length with the symbolic perception of reading, since much experiment has been devoted to this important subject. But other types of symbolism suggest interesting conclusions. Even comparatively simple geometrical figures may tend to arouse symbolic meanings. Bartlett (1916) quotes the case of a mathematical student who, presented with a drawing of a series of wavy lines, stated that they reminded him of a 'determinant'. But spontaneous understanding of the symbolic meaning of certain kinds of perceptual material may be a matter of great difficulty to those who are not experienced in performing this activity. It was shown by the author (1946) that observers with little training in the use of graphs and charts of statistical data had very considerable difficulty in understanding the information which these graphs and charts were intended to convey. The observers were able to perceive and remember, for instance, the number and direction of curves in the graph, and even to reproduce these with fair accuracy; but were unable to take the further step of saying, for instance, 'this graph shows that the average length of life has increased in recent years', or that 'the death rate decreases with increase in the wage rate'. These results suggest that a gradually greater and greater elaboration of meaning may be attached to simple perceptual data as the result of special experience. The trained observer will proceed directly to consider this meaning, while the untrained observer stops short at the stage of cognizing the overt shape.

The enormous amount of data which has been accumulated on 'magic' symbols, archetypes, etc., is not considered here. It is sometimes suggested that the observer, or at least his 'unconscious mind', leaps straight to the hidden meaning of these symbols. But the evidence is not conclusive, and the subject lies outside the scope of this book.

(5) THE 'FIGURE-GROUND' HYPOTHESIS

We noted that the first step of the perceptual process was characterized by a vague impression of 'something there', which passed on to the stage of the generic object when there is a general impression that the visual stimulus is connected with some kind of object existing in the field. It is thus apparent that, at these stages, there is ~~a~~ differentiation of one part of the field from the rest, and that the one part which becomes the main percept is discriminated from what remains in the background. The Gestalt psychologists have called this the 'figure-ground' phenomenon (a term suggested by Rubin, 1921) and have emphasized the importance of this aspect of the perceptual process as a primary factor in the organization of the perceptual field. In other words, they consider that the first essential stage in perception is the emergence of one principal part of the field which is the 'figure' from the remainder which is the 'ground'. Moreover, perceptual experience never continues at a flat level; there is always a differentiation of the 'figure' which is central in awareness from the 'ground' which is perceived vaguely if at all. According to Senden (1932), congenitally blind patients obtain this primary experience almost immediately after operation for cataract, before they can perceive objects as such.

Various other characteristic features differentiate 'figure' and 'ground'. Thus the 'figure' has form, and appears solid and highly structured. The 'ground' has no form and is in the nature of 'substance'. The 'figure' has 'surface colour', that is to say, its colour is localized on its surface and is resistant to penetration; but the colour of the 'ground' is 'filmy', soft and yielding, ill-defined and not definitely localized. The 'figure' may actually appear to stand out in front of its 'ground'. In general, the 'figure' has 'thing character', is more insistent and usually central in awareness, and is more likely to have connected with it various meanings, feelings, and aesthetic values; it is thus named sooner and remembered better. Thus we see that the 'figure' is the important and striking part of the field, and the 'ground' is the background provided by the remainder of the field.

✓Wever (1927) has studied in some detail the process of the arising ✓ of the 'figure' from the 'ground'. He has described a series of stages which occur in the gradual emergence of the 'figure' from the 'ground', as perception takes place. The first four stages, which are necessary to the emergence of the simplest 'figure', require an exposure of as little as 10 σ. They are as follows:

✓ (1) Heterogeneity between the 'figure' and the 'ground', each of which forms a unit;
(2) A minimum brightness difference between the two which gradually increases—this stage is simultaneous with (1);
(3) A region of separation which appears when (2) has reached a certain magnitude, and eventually narrows down to become the contour;
(4) Shape, however, appears before the contour is definite.

For good 'figure-ground' experience, certain further stages may occur; and may be completed in a further period of 7 σ.

(5) Protrusion of the 'figure' out and away from the 'ground';
(6) Definite depth localization of the 'figure';
(7) Surface texture of the 'figure', filmy texture of the 'ground';
(8) Halo round the 'figure'—a simultaneous contrast effect.

The durations given by Wever are minimum figures. Ehrenstein (1930) has shown that the time necessary for the 'figure' to become perceptible varies with the complexity and degree of meaning of the 'figure'. If we compare these stages with those described in section (2) of this chapter, we see that here far more stress is laid upon the emergence of the structural qualities of the percept, and less upon the meaning and classification according to previous experience. Indeed, Douglas (1947) considers that although 'figure' and 'ground' separation was a characteristic part of the perceptual process, leading to the perception of form, it did not seem to be primary, but to be preceded by much transitional effort (but cf. Senden, 1932). Neither did the achievement of the 'figure-ground' separation necessarily lead to the understanding of meaning; dominance of certain parts of the form was also necessary.

It seems clear that the structure of the 'figure' proceeds essentially from its *contour*; but the 'ground' is unaffected. If a 'figure' is uncontoured and is of equal brightness with the 'ground', though differently coloured from it, the 'figure' will appear also soft, ill-defined, and fluctuating, and will tend to shade into the ground (the 'Liebmann effect', demonstrated by Liebmann, 1927). But if a contour line is introduced round the 'figure', the latter will become more impressive, palpable, stable, well-defined, and localized, with its colour hard and glossy rather than soft and spongy (Koffka and Harrower, 1931). Even a white contour line can produce this effect.

Again, experiments of Lauenstein are reported (1942) in which the observers were shown shadows, cast on a background, of concealed figures cut out of cardboard. The sharpness of the outlines of the shadows and their brightness contrast with the background could be varied unknown to the observers. When outlines were sharp and brightness contrast high, the shadows were perceived as 'things'. When the outlines were very blurred and the contrast slight, they were seen as 'blots' on the background. With intermediate degrees of sharpness of outline and brightness contrast, they appeared as shadows cast on the background. Details of this experiment are not available. But if the results were reliable and consistent, they indicate that contour and contrast are essential characteristics for the perception of ambiguous shapes as 'things'.

Further results relating to the importance of contour were obtained by Werner (1935). He found that if two forms were exposed successively, in the same position, at rapid intervals, the first being a black disc and the second a black ring the inner diameter of which equalled that of the disc (see Fig. 3 *a*), then the disc disappeared completely and only the ring was seen. But if the ring was exposed first, the disc did not disappear. The disc when exposed first was used to build up the ring, and therefore it lost its separate contour. Hence also it lost its identity. On the other hand, anything which strengthened the contour of the disc—making it striped or spotted or putting projections on it (see Fig. 3*b*)—also strengthened the identity of the disc, and weakened the above phenomenon. Again, if the figures varied in form, the phenomenon appeared only if the contour of the second figure was seen to fit accurately into the contour of the first, that is to say, to lose its contour in that of the first (as with Fig. 3*c*).

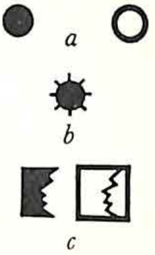

Fig. 3. The disappearing disc figure.

Recently, Michotte (1948) has shown that the experience of the 'ground' is also affected by that of the contour of the 'figure'. The permanent appearance of an object covered over by another object seems to be associated with the fact that the contours of the configuration appertain to the covering object, not to the covered. The latter is not cut out of and delineated by the contour, but continues to exist behind the covering object. But if the covered figure is made to emerge and then to change its size, it will after a time appear as a new figure, with its own contours; the impression of permanence of the original one disappears.

We have already noted that the ability to recognize representations of objects from silhouettes and outline drawings is dependent on the experience of contour in perceiving real objects. Thus it seems that the Gestalt psychologists are correct in emphasizing the importance of contour in relation to the 'figure-ground' phenomenon. As our eyes range over the perceptual field, one part after another of the field becomes 'figural', and there is a constant shift of 'figure' and 'ground' to one part after another of the field. And each 'figural' part appears defined and delimited from the remainder of the field, its characteristic shape standing out as if it were contoured. The contour effect is normally based upon differences of brightness, colour, and distance—but especially of brightness; differences of colour and distance alone may have little effect. The inexpert artist who does not know how to manipulate such brightness differences may find that he has to introduce contour lines into his paintings to make objects stand out from one another. But we are not generally aware of these differences as such, except in so far as they suggest the essential discontinuity of the objects in the environment, and their maintenance of a stable and continuous existence in characteristic shapes. Minor details of the differences of brightness, colour, and distance are ignored—they are 'non-figural'—because they do not contribute to the impression of an environment made up of separate, discrete, stable, and solid objects.

It is clear that the 'figure-ground' process not only contributes to the clarity of perception and the ease of cognition of a complex environment; but also minimizes the effort required to attend to the perceptual field. Only the 'figural' part of the field is central in awareness and is clearly perceived at any one time. This immensely simplifies perception. We shall return to the importance of distribution of awareness, and to certain other features of the 'figure-ground' phenomenon, in Chapter x.

CHAPTER IV

THE DETERMINATION OF FORM

(I) THE PHYSICAL PROPERTIES OF THE STIMULUS AND THE PERCEIVED FORM

We have dealt at some length with the characteristics of the process which occurs when a real object or its representation are perceived. We showed that there was a combination and integration of sensory data, and their assimilation to some category of experience which determined the 'meaning' of the percept as an object or representation, and hence the name given to it. In this process many details of the sensory data were ignored or modified. But in addition to these modifications are others which seem to characterize the perception of form or shape as such. This is by no means entirely determined by the exact sensory properties of the retinal image—the distribution in it of light, shade, and colour. Not only do the perceived qualities of form differ from those of the stimulus pattern and the retinal image; but also they appear to be modified in accordance with certain general principles. These have been formulated and studied experimentally by the Gestalt psychologists. But before their extensive work is considered, it is desirable to study first the work of other psychologists on the 'formal' qualities of visual perception, and their relationship to the sensory stimulus pattern.

The phenomenal percept, then, is never an accurate photographic reproduction of the external stimulus field. This is not to deny that the percept varies as a rule when the physical qualities of the stimulus vary, but that it does so proportionately; there is no 'constancy' of relationship between the variables. Even with the extreme simplification of experimental conditions which is employed in psychophysical experiments, the determinations obtained are at best approximations. Weber's Law even within narrow limits is never a completely accurate statement of events. The 'sensationists' would posit that if the experimental conditions are sufficiently controlled and simplified, the only errors and inaccuracies of response are those produced by the chance factors which introduce variability into the most accurate physical measurements, the so-called 'personal equation'. Their opponents point out that not only has such a state of perfection never been reached, but that it never could be attained without creating in the observer a special type of response, which depends as much upon the observer's training and attitude as upon the physical stimulus. We shall discuss these attitudes in detail in Chapter x. But it may be pointed out here that in general accurate psycho-physical judgements necessitate the acquired ability on the part of the observer to neglect the variations in every other part of the external and internal fields of awareness except those in the one quality to be measured; and to maintain a constant attitude and manner of responding throughout the experimental series. Thus the nature of the percept is not in any sense completely determined by the physical qualities of the stimulus, but is largely a function of constructive tendencies in the individual, some innate and some acquired through experience.

No experimental work is needed to inform us that the percept is clearer, more accurate, and more detailed, the greater, within limits, the intensity, size, clear definition, colour saturation, and duration (time of exposure) of the stimulus object; and also the nearer it lies to the centre of the area of visual regard, and the shorter its distance from the observer, up to the least distance of distinct vision. However, the importance to the clearness of perception of some of these qualities has been studied experimentally. The method has been to expose simultaneously in a tachistoscope two stimuli differing in the amount they possess of two of these qualities; and to alter the degree of one of the qualities in one of the stimuli until the two stimuli are adjudged equally 'clear'. As to the exact nature of this 'clearness' we shall have more to say in Chapter x; roughly speaking, it means 'obviousness' or 'strikingness' or perhaps 'generally perceptible'. The stimuli used were usually two crosses or two circular patches of light. Dewey and Dallenbach (1924), using the 'constant method', found that with one area a quarter the size of the other, the intensity of the smaller had to be six or seven times that of the greater to appear equally 'clear'. From this we may infer that size was more important than intensity as a determinant of 'clearness'.

(2) THE FORM QUALITY OF THE STIMULUS

However, it is the mutual relationship of the physical stimulus qualities in the mysterious organization known as 'form', 'structure', or 'configuration' which is the essential objective determinant of most percepts. A formless percept is unthinkable, and it is impossible to perceive something formless, should such ever occur. As it is, the physical qualities of the stimulus are almost invariably sufficiently diversified to ensure the experience which we know as form or shape. Thus it is clear that the perception of form is dependent both upon the objective relationships of the stimulus qualities, and also upon the interpretations and organization given to these by the observer during the act of perception.

We have seen that the earliest stage in the act of perceiving may be a mere awareness of light and darkness, without any structural properties. But the awareness does not stop short at this stage; it continues to develop until it reaches at least the stage of the generic object. Helson and Fehrer (1932) tried to show that the threshold intensity for just noticeable light to that for just noticeable form is as 1 to 14·4; that is to say, that the former can be perceived at a much lower intensity than the latter. But Wilcox (1932) points out that in the first case the observers did not respond to mere light, but to form, a light circular patch on a darker ground. The second value obtained referred to the perception of the stimulus form. Perception of form does not mean necessarily perception of the objective stimulus form; it is inherent in a mere differentiation of the field into unlike parts.

The clearer the differentiation and the more definite the boundary lines between the parts of the stimulus, the clearer and easier the perception. Thus, using the same technique as that used by Dewey and Dallenbach (1924) for finding the effect of size, Meads (1915) found that the 'clearness' of a clearly outlined cross illuminated through 133 degrees of an episcotister was equivalent to that of a vaguely outlined patch of light with no episcotister interposed. Woodrow (1916), again, measured the length of reaction time to decrease in intensity of illumination of a definitely outlined square, and of a vague spot of light; he found that the time for the former was less affected by the irregular duration of the period preparatory to reaction than was that of the latter. The effect of definiteness of outline decreased with increase in the absolute difference between the intensity of the stimulus and that of the background. Presumably when the absolute difference was great, the structuring of the field was provided by intensity differences alone.

Normally, however, the visual field consists of something more than a simple patch of light upon a dark ground; it is diversified into a number of parts, often quite different from and unrelated to each other. In such a case, it is usual for some type of spontaneous grouping or arrangement of the field to occur. When the field is regarded by the observer for a considerable length of time, he may perceive a structural arrangement which is complex and fluctuating. Thus Schumann (1900), and later Zigler (1920), showed that under the influence of this tendency, a large number of dots, lines, or squares distributed at random might take on various phenomenal groupings ✓. These might acquire the meaning of objects, with corresponding phenomenal changes in their sensory qualities such as fluctuations in clearness or colour saturation, change of position, and so on. To this tendency was given the name *Gestalt-qualität*, previously ✓ used by von Ehrenfels (1890) for similar auditory phenomena. If, however, the field is exposed only for a very short time, so that the attentional attitude is acting powerfully and awareness is intensely directed upon the field, it is usually found that the tendency is to group the separate elements into units as few in number as possible, but each of an easily apprehended internal structure. As was indicated above, this tendency seems to function in order to narrow down the range of awareness. If the elements are not too many, they can be combined into a single unit, the internal structural arrangement of which is readily perceived and imaged, or named and verbally described, so that the actual number and distribution of the elements can be determined afterwards by a more prolonged examination of the primary memory image, or by a process of deductive reasoning emanating from the name or brief verbal description. So widely spread is this unifying tendency, at least in adults, that James (1908, p. 407) comments on Jevons' so-called 'attention' experiment (to show the number of beans which could be instantaneously apprehended when spilt from a handful on the table) that it tells us nothing of attention, but measures the distinctness of our vision and the amount of association between seen arrangements and the names of numbers. The introspections of the observers, in an experiment by Oberly (1924) on the number of black dots on a white ground which could be perceived tachistoscopically, seemed to show that there is a primary level of perception at which no such grouping occurs. But again it seems probable that perception never stops short at such a stage, and that grouping, at least in the primary memory image, is the normal event in adult perception. Glanville and Dallenbach (1929), however, termed this primary level the 'unit' level, at which impressions were apprehended as separate units; and considered that it did occur with simple material, such as a small group of small black rectangles, with a low degree of cognition. When conditions were more complex, the impressions were apprehended as a group. Finally, the reports were mediated by various experiences such as counting from the primary memory image. In apprehending a large number of forms exposed simultaneously, grouping was dependent less upon the objective arrangement of the forms than upon the subjective attitude of the observer (Gill and Dallenbach, 1926). The ability to group improves with increase in age. Thus Brownell (1928) found that the percentage of those who grouped the dots, when a large number were presented together, rather than simply counting them off, increased from eighteen in the youngest children to eighty in those of about twelve years. According to Freeman (1911), adults were much better than children at estimating number when the dots were numerous and irregularly grouped, on account of their greater facility in subjective grouping. The estimation of number is thus largely dependent on facility in grouping.

But it is also found that if the objects in the field are so distributed as to form a structure which is easily apprehended by the observer, the perception of the total field will be easy, rapid, and accurate. A number of general principles seem to operate in producing easy apprehension. Very naturally, the *simpler* the pattern or structure, the easier it is to perceive; Hempstead (1900) demonstrated this with outline figures partially obscured by an episcotister. Dallenbach (1921) also showed that the more complex the figures to be perceived—that is to say, the greater the number of objects on the stimulus card—the more chance there was of 'subjective perceptions' occurring, and of inaccuracy in the subsequent reports or reproductions of such figures. By simplicity we may mean mere fewness of parts in the structure. But simplicity is also attained by *regularity* and *symmetry*; and Goldscheider and Müller (1893) showed that regular and symmetrical arrangements of dots and lines were more accurately and rapidly perceived than were irregular ones. Hempstead (1900) found that, when the presented stimulus material was asymmetrical, lines and angles were often altered or omitted in an immediate reproduction, to make the figure appear regular and symmetrical; though whether this alteration took place during the original perception or the subsequent reproduction is difficult to say. The combination of separated parts of the field to form a *continuous* pattern also occurred in these reproductions. Ponzo (1928) reported that the elements in the field actually seemed fewer in number and nearer together when they were joined in a continuous pattern than when they remained discrete. Biemüller (1932) found the same thing for well-organized, as against unorganized, arrangements of objects such as marbles.

Not only is perception of a particular part of the field largely determined by the structural formation and arrangement of that part, but it may also be affected considerably by the structural properties of the surrounding parts of the field. It has been pointed out that it is very difficult to isolate one part or one aspect of the field. Only highly trained observers can do this with even partial success; others inevitably take into account the surrounding parts of the field. A familiar example of this is shown by the effects of framing a picture;

the picture seems to become intensified, and to stand out more clearly. Further demonstrations are afforded by certain visual illusions, notably the Müller-Lyer illusion. Here the observer, instead of comparing the two horizontal lines and ignoring the arrow-heads, compares the total lengths of the two parts of the figure including the arrow-heads. Practice in making this comparison, however, may enable the observer to restrict his awareness to the horizontal lines, and the illusion is then largely destroyed. But this occurs only when there is prolonged observation of the figure. In momentary observation the illusion persists, because the process of restricting awareness to the horizontal parts requires time; this was demonstrated by Lewis (1908). Many of the familiar visual illusions depend on this sort of effect, for instance, one of those used by Ponzo (1928) which is shown in Fig. 4; here the two lines of dots appear to be of unequal length.

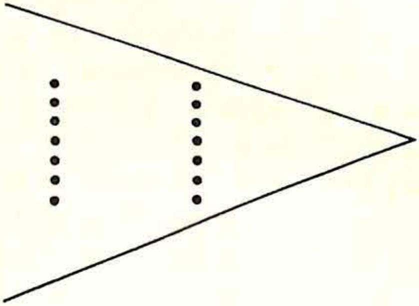

Fig. 4. The effect of surroundings upon perceived length.

But the difficulty of isolating single parts appears in even simpler presentations. Thus Piaget (1944) showed that the same effect occurred if two equal lines A_1, A_2 were presented (see Fig. 5), one of which was joined to a shorter line B_1, the other to a longer line B_2. Then there was a tendency to see A_1 as longer than A_2, because A_1 is lengthened by contrast with B_1, and A_2 is shortened by contrast with B_2.

An extensive series of experiments demonstrating similar effects were carried out by Piaget (1942) and by Piaget and Lambercier (1944) on 'Delbœuf's illusion' and 'Usnadze's effect'. In the former, a circle surrounded by a larger circle was equated to a third circle not so surrounded. In general, there was a tendency to over-estimate the first circle when it was close to the surrounding circle; this tendency rose to a maximum when the radius of the inner circle was about three-quarters of the radius of the outer circle. As the size of the outer circle was increased, the over-estimation decreased, became zero, and was replaced by under-estimation when the radius of the inner circle was approximately one-quarter that of the outer circle. The under-estimation decreased to zero as the outer circle was made larger still. This effect Piaget attributed to a tendency to 'centre' perception upon the central zone, and hence to over-estimate its size by comparison with that of the peripheral zone, which tended to be under-estimated. The further apart the two circles, the less the tendency to do this. The effect was greater with children than with adults, because the latter were more able to dissociate the inner from the outer circle.

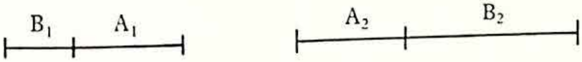

Fig. 5. The effect of lengths upon each other.

In studying 'Usnadze's effect', first, two unequal sized circles were presented side by side, with the greater on the right. When afterwards two equal circles, similar in size to the first pair, were presented, then there was a tendency to under-estimate the size of the right hand of this pair of circles, by contrast with the previously presented larger circle. The contrast effect was increased if the original pair of circles was presented several times over. Moreover, it was transferred to other figures of different shape. But it was gradually extinguished by the successive presentation of pairs of equal circles. Here then the influence of the whole field upon one part of it was preserved over a period of time, hence resembling Köhler's 'figural after-effect' (see p. 67).

Rather similar phenomena showing the effect of the total field upon the apparent brightness have been discussed by Bartley (1941). Fry and Bartley (1935) used a small disc test object A (see Fig. 6 *a*) surrounded by a field B bounded by a dark ring, which was again surrounded by another field C. The total area B + C was kept constant, and the distance of the dark ring from A varied. Then as the ring was moved away from A, the differential brightness threshold between A and B decreased. The ring had the effect of framing or acting as a boundary to A + B, and diminishing the boundary between A and B. Again, with a figure used by Dittmers (see Fry and Bartley, 1935), it appeared that the differential brightness threshold between the areas A and B (see Fig. 6 *b*) was lowest when the brightness of B was equal to that of the surrounding area C. Increasing the brightness difference between B and C presumably made the boundary line act as a frame, and raised the threshold, that is to say, diminished the boundary, between A and B.

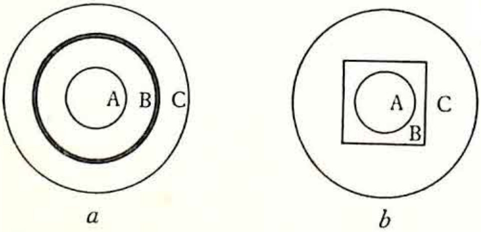

Fig. 6. The effect of surroundings upon apparent brightness.

As we shall discuss in greater detail in Section (6) below, children are more affected by the influence of the total field upon its constituent parts than are adults. Thus Piaget (1947) showed children two equal areas of cardboard upon which were placed equalized wooden blocks. The blocks on one area were placed close together, but those on the other area were scattered about. The children were asked whether the uncovered areas of the two pieces were of the same size. As the number of blocks was increased, there was an increasing tendency to state that the area left uncovered by the scattered blocks was less than that left uncovered by the contiguous blocks. In other words, the former blocks appeared to the children to cover a larger area than did the latter, because they bore different relationships to the total field.

The total field may even have an effect which is extended temporally, as was shown many years ago by Binet (1900). This phenomenon again was more effective with children than with adults.

These children (aged seven to ten years) were shown a series of lines, one at a time, which gradually increased in length, and were required to reproduce each one in turn. The series contained four 'catches'—lines of the same length as those which immediately preceded them. There was a general tendency to make the reproductions of these lines longer than those of the preceding ones, although they should have been of the same length. No child avoided all the 'catches', though some avoided some of them. Hence then the total field consisted of a series of lengthening lines, and a lack of increase in length was ignored.

Much work has been performed to determine the influence of the nature of the individual parts upon the formation of the total structure. But the results have often been ambiguous, because the essential importance of the total organization has been neglected, and the parts have been studied as separate entities, apart from their membership in the group or unit. This seems to have resulted from a preoccupation with the question of the ability to estimate number—or rather, numbers—of objects of different shapes, colours, and sizes, and so on. This again has been an offshoot from the study of the perceptual span, or the span of apprehension, or the span of attention—conceptions, as we have endeavoured to show, of singular uselessness when they are divorced from the structural properties of the field.

We must bear in mind that two somewhat opposed tendencies affect the grouping and the perception of the separate objects in the field. Firstly, there is a tendency towards unification; and objects which group readily into units are easily perceived as grouped. Secondly, there is a tendency towards structural differentiation in the group; thus objects sufficiently diverse in nature to produce a characteristic structure are easily perceived as standing out from the group. In conformity with the first tendency, we find that the mere gross number of parts perceived may be greater if these parts are homogeneous. Thus Brown (1929) found that a larger number of coloured dots was perceived if they were homogeneous in colour than if they were heterogeneous. Wagner (1931) found the estimation of areas of figures to be more accurate if the same kind, rather than different kinds, of figures were shown side by side. And Lorenz (1912) found that the accuracy of judgement of the number of lines in a group was greater if the lines were of similar length than if they were of dissimilar length.

But if one desires to perceive the exact nature of the structure and grouping of the parts, not merely their number, then heterogeneity of parts is desirable. Thus Ranschburg (1902) found that larger numbers of digits were perceived correctly when heterogeneously grouped (e.g. 91385) than when homogeneously grouped (e.g. 654536). Groups which are relatively easy to perceive, which have a comprehensible structure and method of arrangement, will on the whole appear less diffuse and disjointed, and more fully integrated. Thus their parts may seem fewer in number than is actually the case; while the loosely articulated group will appear to have a larger number of parts than it really has. We find that certain qualities of the parts in a group will tend to produce this over-estimation, others to produce under-estimation. Ponzo (1928) showed that if the elements or parts were regular in shape they appeared fewer in number than if they were irregular, just as they appeared fewer when connected in a regular pattern. Messenger (1903) showed that if a number of dots was scattered irregularly over a large field, their number was usually over- rather than under-estimated; and that over-estimation increased with increase of scatter. The same effect occurred when the size of the individual dots was increased. This illustrates the converse principle, that mere number or obtrusiveness of the parts may increase the apparent size of the whole. The phenomenon is well known in the illusions of 'filled' and 'unfilled' space and time. Lewis (1912) found that the 'filled' spatial interval continued to increase phenomenally (relative to the 'unfilled'), as the number of parts or objects in the 'filled' space increased, until there were too many parts to be attended to separately. But this tendency no longer operated once the parts of the 'filled' space were so numerous as to be regarded as a grouped whole.

(3) DEMONSTRATION OF THE GESTALT LAWS AND PRINCIPLES

We have seen then how important in perception are the structural and formal qualities of the field. But it is the *Gestalt* psychologists—Wertheimer, Koffka, Köhler, and their followers—to whom we owe the great development in the study of structure and organization. In a revolt against sensationism and associationism, they stressed in season and out of season the theory that no perceptual field (or indeed any field of consciousness) can be said to consist of a number of elements apprehended sensorially, with some form of structure or relationship or meaning erected by the individual, superimposed upon these at the cognitive level. 'Organization in the sensory field originates as a characteristic achievement of the nervous system', says Köhler (1929, p. 173). This organization results in the presentation to the individual of a series of structures or configurations (*Gestalten*); and the whole field is made up of these groupings and sub-groupings. 'There is a spontaneous tendency to segregate the genuine parts of the field into "wholes" or groups, their genuine parts again as subordinate wholes' (Wertheimer, quoted by Köhler, 1929, p. 140). This primary principle relating to the tendency to organize the perceptual field is exemplified firstly by the 'figure-ground' phenomenon, which we have already discussed. The first stage in the organization is the differentiation of the field into these parts, the 'figure' and the 'ground'. But the field will also tend to be perceived with a greater degree of structure and configuration than this. We have already mentioned the fact that even objectively formless fields, such as dotted fields, do not appear merely as a mass of dots, but as organized groups of dots. The method of organization of these parts will be described in more detail in section (4) of this chapter. In general, the differentiation and organization of the field will take place in accordance with what has been called the *Law of Prägnanz*. The structures or configurations which are differentiated from the surrounding 'ground' will tend to be as 'good' as possible, that is to say, as clear, impressive, and stable as possible. If the objective qualities of the field, what Koffka (1935) has called the *external forces*, are not such as to give rise spontaneously to 'good' configurations, then there is a tendency for the *internal forces* within the individual to modify the pattern of retinal stimulation in the direction of a configuration possessing more 'goodness'. The criteria of 'goodness' necessarily vary from situation to situation, but they include such characteristics of the configuration as simplicity, symmetry, regularity, unification, continuity, inclusiveness, good articulation. If internal and external forces reinforce one another, then a very clear and stable percept results, as, for instance, of a well-illuminated black circle on a white ground.

If the external forces are comparatively weak, as with short exposure, peripheral vision, weak illumination, then the operation of the internal forces may appear clearly. Thus Hempstead (1900) demonstrated the tendency to reproduce material imperfectly seen through an episcotister with more symmetry, regularity, and rectilinearity than appeared in the original. Granit (1921) and Perkins (1932) confirmed these results, using irregular outline figures exposed for short periods of time; the former added also a tendency towards rhythm. Hubbell (1940) also found that if observers were asked to modify dotted figures in order to make them appear as 'good' as possible, there was a strong tendency to differentiate the structure in such a way as to enhance the unity, simplicity, or symmetry of the original.

A natural corollary of the tendency towards symmetry and regularity is that an arrangement which is itself simple, symmetrical, regular, and rhythmical will be more readily and more accurately perceived. The experiments of Goldscheider and Müller (1893) and Hempstead (1900), described on p. 51, demonstrated this tendency to perceive symmetrical material more readily.

Many experiments have demonstrated the operation of unification, continuity, inclusiveness, and good articulation. This tendency towards continuity and completion was shown by Hempstead (1900) and Perkins (1932). Discontinuous parts of the figure were joined together to form complete figures, or lines were added. A familiar example of this tendency to continuity and completion is provided by our neglect of the gap in retinal stimulation produced by the blind spot, even in monocular vision. Thus, if a cross is viewed in such a way that its centre falls on the blind spot, it will appear as a complete cross. A similar result was obtained by Fuchs (1920) with hemianopic patients. If part of a circle was presented in such a way that the incomplete part fell on the blind area of the retina, the patient saw a complete circle.[1] In these two cases the external forces were altogether absent. But even if they are operative—when the observer is aware that the field is objectively discontinuous—he may easily construct a closed figure from the discontinuous parts. Thus three spaced dots are easily seen as a triangle; and Thurstone (1944) has given other more elaborate examples of the construction of figures from spaced dots (see Fig. 7). The closer the dots together, the stronger becomes the impression of a closed figure. Bobbit (1942) again showed that if a series of parts of triangles varying in incompleteness are shown tachistoscopically, a threshold point is reached when the impression of 'two-ness' is replaced by the 'one-ness' of a single closed triangle. This closure occurs sooner with

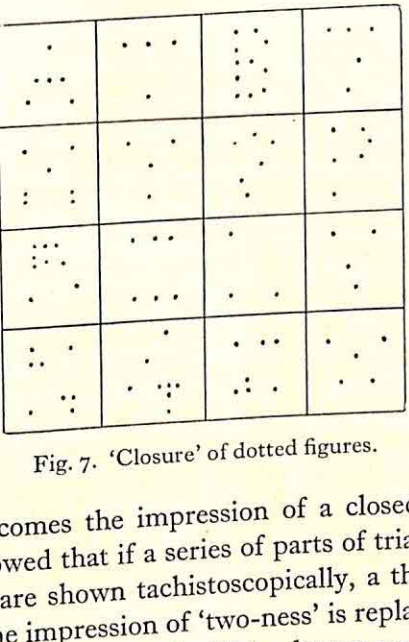

Fig. 7. 'Closure' of dotted figures.

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[1] Recent work of Bender and Teuber (1946a) showed that patients with occipital lesions will see an actually complete figure as complete even though a part of it falls in their 'blind' area. But when an actually incomplete figure is presented so that the incomplete part falls on the blind area, some continuation of the figure may occur, but it is not fully completed, and does not appear as 'good' as does an actually complete figure.

more acute- than with less acute-angled triangles, indicating that the organization and the impression of triangularity is stronger with the former, that is to say, its 'goodness' is greater. Hubbell (1940) again found that subjects who were asked to alter dotted figures in order to make them look as 'good' as possible enclosed 70 to 80 per cent of them either wholly or partially by outlines. This tendency ✓ towards continuity is called by Koffka (1935) the *Law of Closure*. It also has its corollary that continuous closed figures show more stability and persistence than do discontinuous ones. Though some of the examples he shows are not very convincing, yet it seems probable from the results of work on memory for forms that this principle holds. Thus Wulf (1922) has shown that with forms presented once and reproduced at subsequent intervals, no originally closed figure falls apart or becomes discontinuous at subsequent reproductions.

Bakay and Schiller (1948) presented to their observers a series of figures which in several cases consisted of two separated parts of a closed figure, and asked them to make a single manipulative change to each. There was a strong tendency to 'close' those figures the parts of which were separated. There was also a tendency to orientate figures symmetrically with the horizontal and vertical, or with the main axis of the background. Separate equal-sized figures were placed parallel or perpendicular to each other. In other words, 'closed' balanced or symmetrical figures were most favoured.

A closely related characteristic of the 'good' configuration is its ✓ *inclusiveness*. Other things being equal, the perceived configuration will tend to include as much of the field as possible. Other things, however, seldom are equal; and we shall describe certain cases in which inclusiveness is the dominating factor, and others in which simplicity and continuity are more important.

A good example of the former is shown by the experiment of Heiss (1932). Heiss presented children with two groups of pieces, such as the pieces of a jig-saw puzzle, one of which had one piece missing, and instructed them to find that piece in the other group. If the latter formed a complete design, the children took far longer to find the missing piece in it than if it was an unorganized group.

Gottschaldt's results (1926) went even further than this. In order to discover the importance of experience and familiarity, he presented to his observers a number of simple figures for one second each; some of these were presented three times only, some 520 times. The observers were instructed to learn the figures. Afterwards they were presented with a series of complex figures, each exposed for two seconds, and each containing within it one of the simple figures (see example in Fig. 8). There were several complex figures corresponding to each simple one. The observers were instructed merely to describe the complex figures. It was found that very few cases occurred when the observer either noticed that one of the simple figures was contained in the complex one, or even guessed that it might have been there. It happened in 6·6 per cent of cases when the simple figure had been presented three times, and in 5·0 per cent of cases when the simple figure had been presented 520 times. Clearly in this experiment familiarity as produced by repetition of perception of the simple figures had no effect at all. The more complex figures included the simpler ones so successfully that the latter were imperceptible.[1]

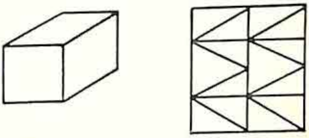

Fig. 8. The effect of inclusiveness.

But Galli and Zama (1931), using rather different types of figure, found that the larger configuration must itself possess more 'goodness', and form a more unified whole, for this masking effect to occur. If we compare one of Gottschaldt's rather more obvious pairs of figures (see Fig. 8) with one used by Galli and Zama (see Fig. 9) in which the simpler configuration to be detected is a square, we can see at once how different is the task in the two cases. Though Fig. 9 shows one of the more difficult ones used by Galli and Zama, its effect is simply to mask and make more difficult the detection of the square. In Gottschaldt's figure, however, the simpler figure no longer exists phenomenally; it has become submerged and lost in

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[1] It may of course be noted that a single exposure of two seconds duration would give the observer enough time merely to get a general idea of the shape of the complex figure, and no time at all to analyse out its constituent parts.

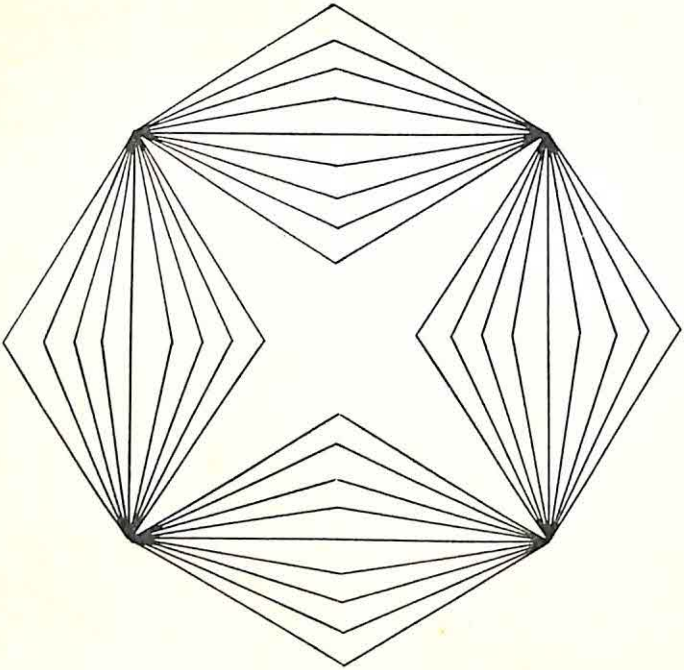

Fig. 9. The effect of 'goodness' of configuration.

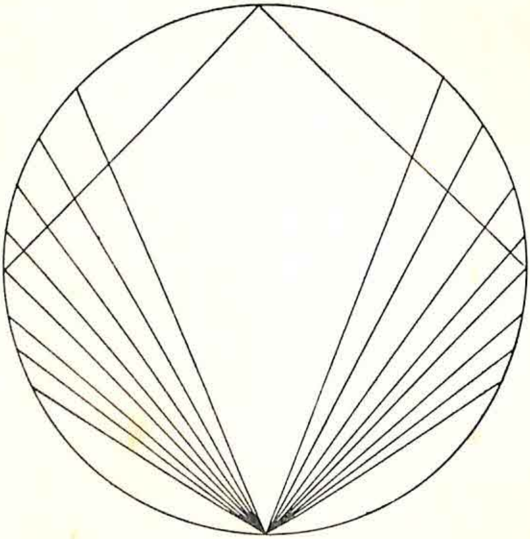

Fig. 10. The effect of lack of continuity.

the larger whole, and in so doing has completely altered its identity. This illustrates admirably how impossible it is to see the parts of a unified whole as separate structures. Again, if we compare the figure shown in Fig. 9 with that in Fig. 10, we see the importance of continuity. Fig. 9 forms a much better configuration than does Fig. 10 because it is an enclosed area with continuous contours.

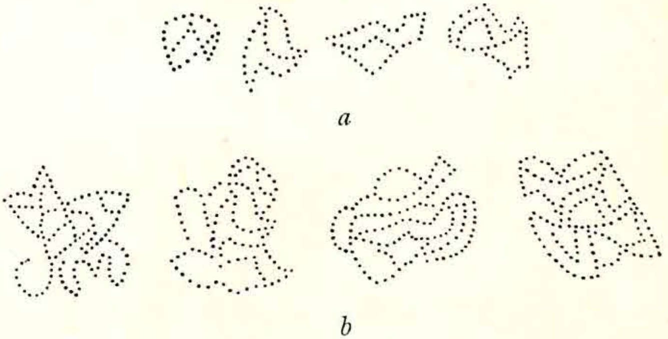

Fig. 11. The effect of learning.

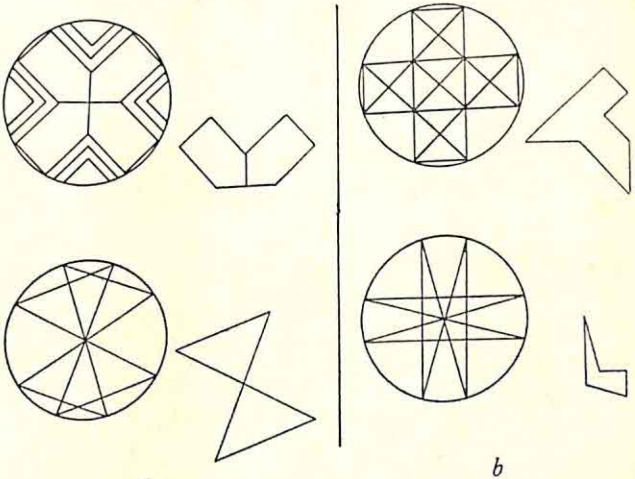

Fig. 12. The effect of 'goodness' of the parts.

Djang (1937) used another different type of figure, and also showed that if the simple figures (see Fig. 11 *a*) had been thoroughly well learnt by the observers, they were much more frequently recognized in the complex ones (see Fig. 11 *b*) than were simple figures which had not previously been learnt. Campbell (1941) also showed that if observers were instructed to 'see out' a particular part of a whole design, i.e. to see it as a well-defined unit within the whole, this took two to three seconds if the part had a 'natural' or 'good' (regular, symmetrical, coherent) structure of its own (see Fig. 12 *a*). But it took twenty to forty seconds if the part had an 'unnatural' (irregular, incoherent) structure (see Fig. 12 *b*). Thus we must conclude that the important factor is not necessarily the inclusiveness of the larger pattern, but rather the relative 'goodness' of the whole and the parts. But it is also true that Köhler (1929) has constructed patterns in which even familiar figures such as 4, K, H, and E are so firmly embedded that they are completely masked by the larger configurations of which they form part.

(4) THE RELATION OF THE PARTS TO THE WHOLE

Although the Gestalt psychologists stress the importance of the unified whole rather than of the parts into which it can be analysed, nevertheless they would not deny that the complete determination of configurational laws must include some study of the parts. They would maintain, however, that since the whole is different from the sum of the parts, such a process is liable to destroy the essential nature of the configuration, and to substitute for it a collection of entities bearing little or no relationship to the original. Consequently, the parts must always be studied in relation to their ✓membership of the whole which conditions them.

Their relationship may go as far as to change even the phenomenal sensory qualities of the parts of the stimulus field. Thus Fuchs (1923a) states that if nine circles are arranged to form a square (three by three) with the outer ones alternately blue-green and yellow, and the central one neutral, then if the configuration is seen as a blue-green square with a yellow cross within it, the central circle will appear yellow; but if the configuration is seen as a blue-green cross tilted to the left and a yellow square also tilted, the central circle will appear blue-green. That is to say, a single isolated part tends to become assimilated to the configuration to which it coheres; and Fuchs (1923a & b) considered that the degree of assimilation depended on the degree of coherence. This theory was supported by the results obtained by Tudor-Hart (1928) and by Heider (1933) in their experiments on the *transparency* phenomenon. A number of yellow discs were arranged upon a black screen to form a structure such as a circle, and a blue episcotister was then interposed between the observer and the screen in such a way that a variable number of these yellow discs were seen through the blue 'transparency' produced by the rotating episcotister. At first the outlying field (the part of the field which was not behind the transparency) was covered from the observer's view. The discs of the inlying field (seen through the transparency) then appeared neutral or bluish. When the outlying field was uncovered, the discs of the inlying field appeared to become yellower, since they entered the same configuration as the yellow discs of the outlying field. This increase of saturation could be measured by increasing the size of the blue sector of the episcotister until the discs again appeared neutral. And it was shown by Tudor-Hart, and more conclusively by Heider, that the increase in size of the blue sector was proportional to the structural coherence of the parts of the configuration.[1] The more closely knit the parts of the configuration, the greater the tendency of the discs behind the transparency to appear the same colour as those without it.

Similar effects relating to the influence of the whole upon the parts have been obtained for form as well as for colour. Thus Lewin and Sakuma (1925) showed that if a configuration composed of two vertical rows each of three dots were presented binocularly, and if the top dot of the left row were moved to the right, the result was that the middle dot of that row appeared to move half as far, in order to produce an apparently oblique line of dots. Similar modifications of the parts by the whole appear in the familiar visual illusions, and were described on p. 52. Even more striking are the examples given ✓

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[1] This relationship was shown by Heider to depend also upon certain other factors connected with the nature of the transparency; but the main conclusion was not affected.

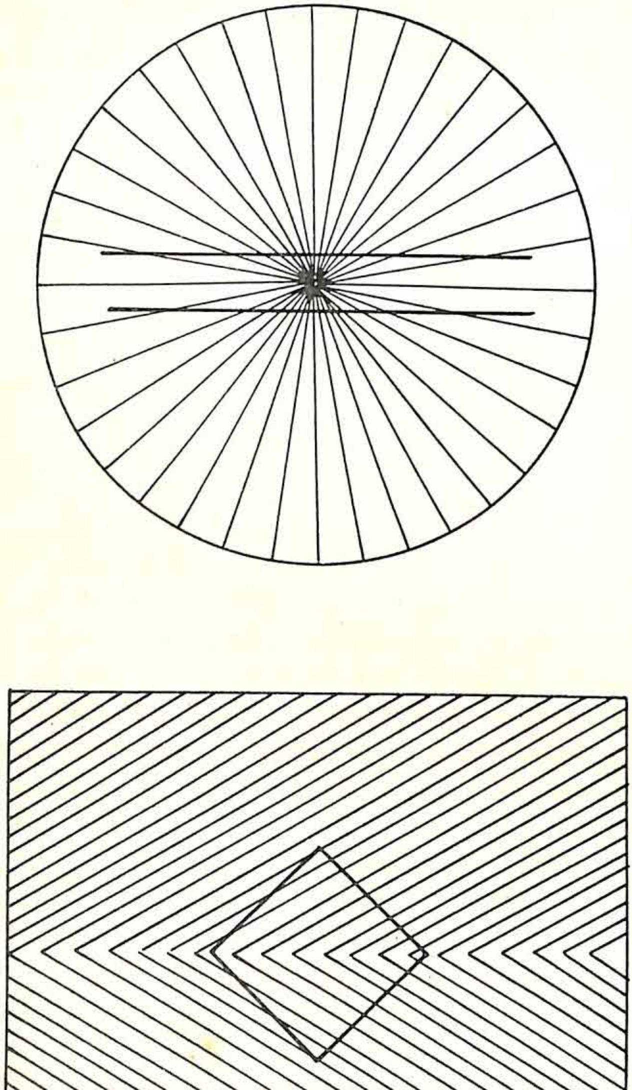


Fig. 13. The effect of the field upon contained figures.

by Orbison (1939). He found that if simple shapes such as a square, circle, triangle were placed to one side of the centre of large complex figures containing parallel or radiating lines (see Fig. 13), then the effect was to distort the outlines of the simple figures, bending them one way or the other. This he explained as being due to the 'cohesive forces' acting at right angles to the lines of the large figure, in conflict with the 'restraining forces' of the retinal stimulus pattern set up by the small figures, resulting in the distortion of their apparent shape. These 'fields of force' and their activities are considered to be of major importance, according to the theory of *physisches Gestalten.*

Berliner and Berliner (1948) quote early results of Hofmann and Bielchowski (1909) which showed that the position of the apparent horizontal and vertical on a field of tilted lines varied with the angle of tilt. Berliner and Berliner then proceed to derive an algebraic formula showing how a geometrical figure superimposed on a geometric field will be distorted at each crossing point, in accordance with the angle of the former to the latter. But Webster (1948) denies the validity of this formula, and states that the effect depends on which part of the figure is fixated, and upon the existence of intercepting lines in other parts of the field. Whether or not we accept the Gestalt explanation of this phenomenon, there is no doubt of the modification produced in the smaller figure when it is projected upon the larger.

Köhler and Wallach (1944) and Köhler and Emery (1947) have shown that similar effects may operate upon a perceived figure by virtue of the after-effects of another figure previously fixated in the same, or a contiguous, position. These they have called 'figural after-effects'. In general, the outline of the second figure, or parts of it, tend to recede from the regions occupied by the first, fixated, figure. If the position of the second figure was inside that of the first, then the former tended to shrink; if the position of the second was outside that of the first, then the former tended to swell. If the two figures overlapped, the part of the first within the second tended to appear smaller than the part without. If the two figures coincided, or were a long distance apart, the second figure was unaffected. If a tilted line was fixated, then another line seen subsequently, whatever its actual position, appeared more tilted in the opposite direction. Similar effects were obtained with three-dimensional figures. If the first figure was a line tilted away from the observer, a vertical line seen subsequently appeared tilted towards him. If two figures were presented successively in different planes, then the effect of fixating the first figure was to push forward the second figure if its position was actually nearer to the observer than that of the second; and to push it back, if its position was actually farther away.

Now it is true that in the case of the familiar illusions, the modified figures are usually integral parts of a coherent whole. But Orbison's and Köhler's figures show similar effects appearing when there are two quite different 'wholes' existing in the same or contiguous positions. It seems therefore that the spatial contiguity of the two forms is sufficient for their interaction; and Köhler would argue that they repel one another like two magnets. It seems possible, however, that the effect occurs only in so far as the observer perceives the two figures to be in some way related or interacting with one another, and to that extent forming a single 'whole'. If he could perceive them as entirely separate and unrelated entities, the effect might not obtain. We have no direct evidence for this statement. But we may note that Bender and Teuber (1946b) have demonstrated the occurrence, in patients with occipital lesions, of a similar bending, curving, or shrinking of figures perceived in the neighbourhood of the affected areas. It is possible that there is a lowering of sensitivity which impairs accurate segregation and separation of parts of the field in such patients, a conclusion supported by a further observation that perception of objects in the affected parts of the field is easily interfered with and even extinguished by perception of objects in the unaffected parts.

✓ In contrast, it is worth studying the relationships between parts of a whole which seem most effective in modifying or stabilizing configurations. Both proximity and similarity in the parts tend towards the formation or strengthening of configurations. The influence of proximity is well seen in the figures designed by Wertheimer (1923), one of which is shown in Fig. 14 *a*. The dots which are nearer together fall into groups or 'figures', with the wider spaces forming the 'ground'. The effect of similarity of parts is illustrated in Fig. 14 *b*; the similar dots tend to group themselves into 'figures'. But, generally speaking, similarity is stronger than proximity. In Fig. 14 *c*, the 'figures' are usually formed from the similar dots rather than from those which are nearer together.

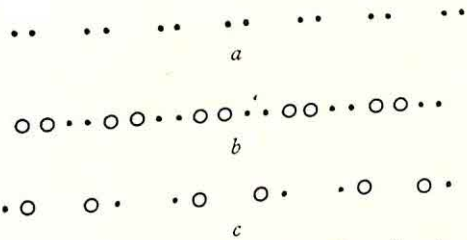


Fig. 14. The spontaneous grouping of parts.

Parts similar to one another which have a common difference from other parts, for instance, of size, shape, brilliance, or colour, tend to fall into a single configuration to which 'closure' is applied. This is exemplified in the Stilling tests for colour blindness (and their later modification by Ishihara, 1936). Here the observer is presented with a number of sheets covered with small patches of colour upon a white or dark background. In each of these, certain of the patches, similar in colour to one another and differing more or less in colour from the others, form a letter or a number. If the colour difference is slight, an individual with a defect involving these colours is unable to see the letter or the number; if his vision is normal, he can pick it out. The amount of defect can be measured roughly by the degree of colour difference necessary to enable the individual to distinguish the letter or number.

In a similar way a single part clearly differentiated will stand out from all the others which resemble each other. Hertz (1928) has described an interesting example of this phenomenon in birds. A group of flower-pots was placed beneath a tree on which a number of pigeons were perched, and beneath one flower-pot food was placed. After the experimenter had gone away, the birds would come down and overturn the pots to get the food. If the pots were arranged in a continuous pattern, the birds had some difficulty in remembering and identifying the one which covered the food. But if this pot stood out from the pattern in some way (for instance, if it stood by itself on the edge of a circle), the pigeons went to it immediately. This phenomenon was also noted by Galli (1931) in the reproduction of meaningless profile forms, perceived tachistoscopically. Certain characteristics of these profiles were emphasized in the reproductions; details which appeared to be detached from the total configurations stood out particularly, and also features which were not repeated regularly and symmetrically in the form of the profile. Again, Ross and Schilder (1934) found that in the tachistoscopic perception of drawings of the human body, certain parts of which were defective or missing, there was sometimes a tendency to see some outstanding part of the drawing as an independent whole, or one of the defects in an exaggerated form. But there was also a tendency to forget these isolated details easily; on further exposure of the figure they became submerged in the totality—that is, presumably, it was already seen that they had no independent existence apart from the total configuration.

(5) THE CONSTANCY OF CONFIGURATIONS

The physical qualities of the stimulus constellation giving rise to a configuration may be varied within wide limits; but as long as the essential structural relationships are maintained, the configuration will be unchanged, and will still be recognizable as being the same configuration. A very familiar example of this principle is afforded by the melody which remains the same when its pitch and intensity are altered (and the timbre of the instrument on which it is played), provided the pitch relations, and to a less degree the intensity relations, are unchanged. Similar examples of this can be adduced in visual perception. Size, colour, brightness, retinal position of the configuration may be altered, without impairing the recognizability of the configuration. Adults will recognize it with more difficulty if its spatial orientation is altered, particularly if it is turned upside down; but we shall give evidence in the next section to show that children are much less affected than are adults by changes of orientation. Evidence on the persistence of recognition of configurations was given in experiments by Dees and Grindley (1947). Observers were trained to react to a series of simple figures by pressing the morse key appropriate to each figure. When the retinal position of the figures was altered, there was no significant increase in reaction time or errors; indeed some observers were unaware of any alteration. When the size of the figures was halved, there was a slight increase in reaction time. But when the figures were turned through 90 degrees, the reaction time increased on the average by 45 per cent (83 per cent for the first transposed figure), although there was no increase of errors.

Again, familiar configurations such as the well-known illusions can be recognized when presented under a number of unusual conditions. Zama (see Gemelli, 1928b) presented an illusory figure to each eye separately, for instance, the two parts of the Müller-Lyer illusion, and found that when they were fused stereoscopically, the illusion persisted. Gatti (see Gemelli, 1928b) presented the two parts of such a complex successively; the illusion was obtained when the first part coalesced with the second. The effect persisted when the first part was no longer actually perceived, but its visual image called up in response to a name previously given it. Leeper (1935) has also shown that once an observer has recognized the configurational nature of an incomplete figure of the type designed by Street (1931; see Fig. 1, p. 30)—that is, he has recognized what it is intended to represent—he will remember this over long periods of time. Similarly, if the observer perceives spontaneously a certain aspect of an ambiguous composite figure, such as Boring's 'wife and mother-in-law' figure (Boring, 1930; See Fig. 15), he will retain that aspect, and will find great difficulty in seeing the other aspect of the complex. Some

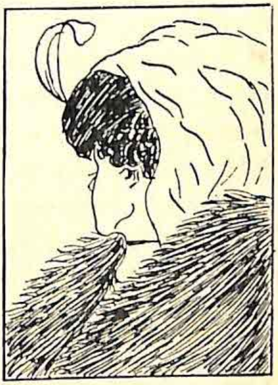
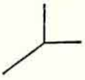
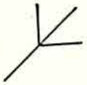
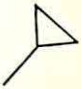


Fig. 15. The 'wife and mother-in-law' figure

experiments of Allport (1930) demonstrated the recall of simple configurations by children over quite a long period of time. Two simple figures (the figures used in the Terman-Merrill test, Form L, Year XI, item 1) were presented to the children aged ten to thirteen years, who were required to reproduce them at varying intervals of time afterwards. It was found that although alterations in absolute size and in the relative sizes of the parts were frequent, in general the characteristic structure of the configurations was retained over long periods of time.

Apart from these memory effects, constancy of configurations may also operate in producing immediate perceptual impressions, such, for instance, as the transparency phenomena to which we have already referred (see p. 65). When an episcotister of one colour, with an open sector, is rotated in front of a screen of another colour, the observer will normally see the former as a 'transparency' situated in a plane in front of the latter. It is impossible for two configurations to co-exist in the same plane and in the same direction, but if one is perceived to lie in front of the other, both configurations can maintain their constancy. The stronger the conviction that there are two planes at different distances, the greater the apparent saturation of the colour of the transparency. The phenomenon may, however, be destroyed, and replaced by a mixture of colours in a single plane, by reducing the size of the screen until it is entirely covered by the episcotister, or by the assumption of a critical attitude on the part of the observer which destroys the two-plane structure (see Fuchs, 1923a).

The constancy of a configuration is sometimes maintained by its contour—another example of the importance of contour in configurational phenomena (see p. 43). Thus a contour already present in the field of view may exert a definite effect upon the consolidation of new contours. Volk (1927) presented figures such as irregular or oblique lines, causing them to appear and disappear rapidly behind a slit with two vertical edges. The contour which appeared first seemed to stick to the one edge and became straightened like it; while the contour that disappeared last was influenced by the form of the edge behind which it disappeared.

It is not surprising that there exists a corollary to the principle of the constancy of configurations—namely, that if any essential structural relation in the configuration is altered, the configurations will change, despite the constancy of all other conditions. In confirmation of this, Gottschaldt (1929) showed his observers, forty times over, a figure  and then a  or a  Unless the observers had previously been instructed that an extraneous figure would appear in the series, they did not recognize either the second or the third figure as arising from the first, but saw them as new figures.

Other alterations of configurations can be demonstrated in which the essential configuration contains elements from more than one sensory mode. Thus Benussi (1913) showed that if two spatial extents were defined by three lights flashing successively, variation in the temporal interval would produce an apparent variation in the relative spatial extents, although the latter had in fact been kept constant. Gelb (1914) has shown the same effect to occur with tactile stimuli. Again, in the size-weight illusion, a change in the visual aspect of the configuration, and increase in size of the lifted weight, produces a corresponding expectation of change in the mass of the object, which is therefore expected to be heavier, and actually appears to be lighter.

(6) VARIABILITY IN THE PERCEPTION OF CONFIGURATIONS

It has in general been the contention of the Gestalt psychologists that the principal Gestalt phenomena operate universally in adults, very frequently in children, and even in many animals. Indeed, it has sometimes been postulated that the tendency to see closed continuous wholes is a primitive one, and therefore operates even more strongly in some animals and in children than it does in adults, where it is supplemented and to some extent replaced by the analytic abilities which develop with maturity. Data from normal experience and corroborative experimental evidence have been advanced to show that at this primitive level of intelligence complex configurations can easily be perceived and recognized where very simple unstructured stimuli are ignored. Thus young children and animals will recognize familiar faces and voices when they will not respond to simple visual or auditory stimuli. Children tend to see pictures as 'wholes' without analysing out the details, according to Smith (1914) (but cf. Vernon, 1940). Again, the Müller-Lyer illusion and the horizontal-vertical illusion were found by Walters (1942) to decrease in amount between the ages of six and eleven years. An interesting example of the strength of Gestalt tendencies in children has been given by Slochower (1946), who required children of five to seven and nine-and-a-half to ten years to make pencil reproductions and two-dimensional clay models of various simple shapes. She found that there was a considerable tendency to improve the structure in making these constructions, with more symmetry, regularity, and rectilinearity than existed in the originals. Further, the tendency was stronger with the younger children; the older ones produced a larger number of faithful reproductions.

But the most frequently quoted experiments which demonstrate the configurational response are those performed by Köhler (1915) on the relative brightness choice by hens and chimpanzees. The hens were trained to eat from a medium grey card placed next either (1) a lighter grey card, or (2) a darker grey card; that is to say, they were allowed to eat from the medium grey card, but driven away from the others. The hens trained with (1) were then given the medium grey and dark grey cards, and it was found that in general they chose the latter; those trained with (2) were given the medium grey and light grey cards, and in general chose the latter. That is to say, in each case they made the *relative choice*, responding rather to the structure or relationship, 'lighter to darker' than to the particular card to which they had been trained to respond. The chimpanzees gave similar results.

There seems, however, to be some doubt as to the universality or even the preponderance of this choice. Thus Köhler (1915) states that, out of eighty-four trials, the hens made the relative choice fifty-nine times (69 per cent) and the absolute choice twenty-six times (31 per cent). Also, only four hens were used. In a later re-test (1917), however, one hen made nine relative choices out of ten, the other ten out of ten. Thus the absolute choice tended to die out with time, while the relative choice was more lasting. Taylor (1932) has criticized these results on the ground that the brightness differences of the cards were too small for hens to discriminate. He repeated the experiment with white, grey, and black cards, and obtained results which contradicted Köhler's. But it seems unjustifiable to assume that the phenomenal relationship in Taylor's experiment was principally one of brightness, as it was in Köhler's. In the former, a phenomenal difference of hue was introduced, that is, of hue on the neutral colour scale; thus the absolute choice may have been based on a recognition of hue. The problem has, however, given rise to much experimental work on the relative *versus* the absolute choice by animals between different shades of grey. Jones (1939) concluded on the basis of his own and other experiments that in the period between the original learning and the re-test the animal had forgotten the brightness of the original 'positive' stimulus. But this conclusion perhaps supports Köhler's original dictum, that a relationship is more easily remembered than an absolute quality. The experiments of Spence on chimpanzees (1941) showed that if the relationship was one of size, then the absolute choice was made more frequently than the relative choice if the stimulus originally rewarded was the largest or smallest of a series of three; but that relative choices were much more frequent if the stimulus originally rewarded was the middle one of a series of three. Relationship was more prominent in the original training in the second case than in the first, and was therefore more readily remembered. Lashley (1938) found that rats could be trained to choose the largest or smallest of three circles only if it was clear that there was a relational series, i.e. when the size differences were not too great. But once they had learned this choice, they would automatically choose the largest white area of three other shapes. Clearly, then, the strength of the configurational relationship varies according to circumstances.

The same conclusions may be drawn from similar work on children. Köhler (1918) obtained results for the choice of greys by a child which corroborated his results obtained with hens. Rüssel (1931) obtained similar results for children aged two to five with stimulus qualities such as contoured-flat, thick-thin, round-pointed, symmetrical-asymmetrical. Kuenne (1946) found that the ability to 'transpose' a size relationship, i.e. make a consistent choice of the smaller of two squares, depended on the difference of absolute size of the squares, and the language facility of the children. Thus if the absolute sizes of the pair of test stimuli differed greatly from those of the training stimuli, only 50 per cent correct choices were made by children of M.A. 3; but 100 per cent correct choices were made by children of M.A. 6. This improvement she was able to correlate with improvement in the use of language. If, however, the difference of absolute size between training and test stimuli was small, all the children made 90 per cent or more correct choices.

Jones and Dunn (1932) repeated Köhler's original type of experiment using relationships of size, form (thick and thin rectangles), brightness (of grey), and colour grades, and found that some children regularly made the relative response, some the absolute, and some were variable. No relationship appeared between the nature of the choice and the mental or chronological age of the child. They also found, however, that the better the original learning, the greater the tendency towards the relative choice. Jackson *et al.* (1938, 1940) worked with children aged two-and-a-half to six years, on visual relationships (size, brightness, width, and number of stripes), and on weight differences. They found that, with a small amount of practice, choice was confused and unstable; rather more practice favoured the relative choice; but still more practice produced the absolute choice, at least with some children. The results also varied according to the experimental instructions, and as to whether the stimuli were presented simultaneously (giving predominance of relative choice) or successively (giving predominance of absolute choice). But again the general conclusion was that the relative stress on either the absolute degree of some stimulus quality, or the relation between two degrees of these qualities, could be varied by the manner in which the experiments were carried out. Comparable results were obtained by Taubman (1945), in getting observers to judge the 'whiteness' of various surfaces on an imaginary scale from zero (black) to 100 per cent (pure white). There was a tendency to judge the darker greys as 'near black' and the lighter ones as 'near white'. It was difficult to use a continuous scale of judgement, and to locate the medium greys. Thus the configurational relationship is not invariably operative, because in certain circumstances the absolute qualities of the stimuli are more obvious. But where these are difficult to identify and remember, then there is a strong tendency for the relative choice to appear.

We shall return in Chapter VI to the consideration of the variability of Gestalt phenomena in children with respect to the 'constancy' phenomenon. There is one particular instance, however, in which it seems that configurational phenomena operate in rather a special way in children—that is, in their ability to recognize shapes irrespective of their spatial orientation. We discussed on p. 71 the effect on the perception by adults of a configuration produced by tilting it through 90 degrees. But children seem to be much less affected by such alterations; the sense of spatial orientation is less closely linked to the horizontal and vertical than is that of the adult. It is found, for instance, that when adults are asked to compare the size of a square tilted on one corner, so that it appears diamond-shaped, with that of an equal square with its sides vertical, they may judge the former to be greater than the latter, because the vertical dimension of the former is greater. But children seem to suffer less from this illusion, presumably because they estimate the size of the tilted square from the length of its sides, and not from its vertical dimensions. This is not to say, as Koffka (1924) rather implies, that no children have the adult illusion. Hanfmann (1933) found that about half the number of children he tested at three years of age over-estimated the size of the tilted square, while 90 per cent did so at six years. And Hartmann and Triche (1933) found that children of six to seven years were not greatly less susceptible to the illusion than were adults. Clearly, then, absolute spatial orientation has developed fairly completely by that age, which is quite to be expected. Hanfmann also showed that to the younger children relative spatial orientation might be more important than absolute. Thus the children were shown geometrical figures containing lines which were vertical, but not at right angles to certain other lines, and asked to reproduce them. They would frequently draw the lines at right angles and not vertical, or else re-orientate the whole figure so that the lines in question were both vertical and at right angles. Asked to reproduce the drawing of the roof of a house with a chimney on its slope, they often placed the chimney on the roof-tree, or made it sprout out perpendicularly to the roof (cf. Piaget's figures, p. 117). Köhler (1939) also quotes result of experiments by Oetjen (1915) which showed that boys had less relative difficulty than had adults in reading print aligned vertically; and of experiments by Mouchly (unpublished) which showed that little children could recognize outline drawings as easily when they were inverted as when they were in the normal position. Since orientation is thus ignored, it is natural that children should have some difficulty in remembering the absolute orientation of objects. Thus Gellerman (1933) showed that two-year-old children who had been trained to choose as positive stimulus a vertically and horizontally orientated cross, had great difficulty in rejecting, as negative stimulus, a cross rotated from that position. On the other hand, Lashley (1938) has shown that with rats the direction of the axis of the figure with respect to the horizontal and vertical is highly important for recognition. It appears that the rat's visual organization is constituted primarily for adjustment in space rather than for identification of objects, and the generalization from specific objects takes place in terms of spatial relations. It is of course clear that the little child has had a much less varied experience than has the rat in orientating itself to the spatial relationships of its environment. Thus we may conclude once more that the configurational phenomena are not equally primitive and fundamental for all organisms, but that their occurrence depends on the particular circumstances and experience of the individual who responds to them. As Lashley says (1938, p. 163), 'behaviour is associated with those [properties of objects] found by trial and error to have functional significance': shape characteristics for children, spatial relationship for rats.

Evidence as to the variability of configurational phenomena in adults is given by the conditioning experiments of Razran (1939). He presented several of Wertheimer's figures (1923; see Fig. 16 *a*) indicated by flashlight bulbs, to adult observers while they ate. Subsequently, parts of these figures were separately exposed (see Fig. 16, *b* and *c*), and conditioned salivary responses occurred. the amount of salivation differing for different parts. Conscious learning was obviated by instructing the observers before the original presentation that the effect of eye strain on digestion was being studied. It was found that conditioned responses to repeated exposures of the various parts developed at different rates. Responses to simpler parts (for instance, *b* in Fig. 16) quickly reached a maximum; whereas responses to more complex parts (see *c* in Fig. 16) took much longer to reach a maximum. Further, when extinction was carried out, responses to complex parts persisted for longer. The experiment showed that perception of the 'whole'—the original presentation—was not entirely divorced from perception of the separate parts. Moreover, perception of one part or parts did not exclude perception of others. Thus there was no one single way of perceiving each figure, but it was seen spontaneously in different ways at different times. The Gestalt principles are thus no more than tendencies, which are fluctuating rather than persistent.

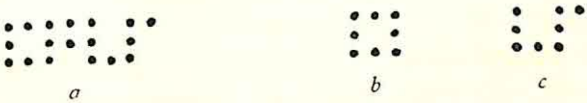


Fig. 16. The relation of the parts to the whole.

Further evidence has been obtained by Thurstone to show that different adults may perceive the same configurations in different ways. He applied factorial analysis to the correlated scores of 170 University students in forty tests of perceptual activity, including susceptibility to a number of illusions, recognition of concealed shapes and pictures, the Gottschaldt figures, etc. (1944). He extracted two important factors, the first of which seemed to relate to strength of closure and ability to perceive configurations when concealed, and against distraction; and the second to flexibility in breaking up one configuration and passing to another (as for instance from the complex to the simple Gottschaldt figures). It seems possible that the first of these tendencies was related to the childish over-determination by perceptual 'wholes', and the second to the more mature ability to analyse up these wholes and re-synthesize their parts in some other setting. It is clear from Thurstone's results that both these tendencies may appear in normal adults. But there is some evidence from brain injury cases that the former tendency is liable to predominate over the latter in cases of impairment of mental function, which again indicates that it may be more fundamental and primitive. In such cases there may be an over-determination by the 'whole' pattern which makes difficult the analysis, abstraction, and re-synthesis of its parts. This appears in the failure of such cases to do tests such as Kohs Blocks. The relationship of perceptual analysis and re-synthesis to the higher mental functions indicates that these processes may characterize the more mature individual. Nevertheless, we shall discuss in Chapter x the relationship of the predominance of one or other of these tendencies to certain characteristic attitudes which are only partially intellectual in origin.

We may then sum up this chapter by saying that the stability of our perceptual impressions is preserved, not only by the assumed continuity of the objects to which they relate; but also by a general tendency towards simplicity, consistency, and integration of shape as such, even when it is not perceived as relating to any 'real' object. Temporal continuity is preserved by the constancy of form relationships; the identity of such relationships may be preserved even when all the elements which enter into the relationship have been altered. Thus we are capable of making abstractions and generalizations, not only in terms of objects and classes of objects, but also in terms of pattern or formal relationship as such. This facility may vary in different individuals, but it appears to operate even in young children.

CHAPTER V

SPATIAL PERCEPTION

(1) THE TWO-DIMENSIONAL FIELD

We have so far confined our discussion to the study of perception of objects and shapes irrespective of the position in which they are situated. It is clear that we not only perceive the relationship of the parts to the 'wholes' which they make up; but also of various 'wholes' to one another, and particularly to ourselves. In fact, from early childhood we are aware of a three-dimensional spatial continuum of objects, extending away in all directions from ourselves the centre. Although at any one time we are directly aware only of a small part of this continuum, yet we do not feel that there is any gap in it; we can fill it at any moment by turning our eyes in the appropriate direction. Moreover, the spatial arrangement of objects about us is steady and constant, and when they change their position, this is done in an orderly and recognizable manner. That objects have such a spatial arrangement is indeed inseparably connected with their identity; as Ames (1946a) has pointed out, the 'thatness' and 'thereness' of concrete objects do not exist as separate entities in their own right. They exist only in relation to one another and to the experiencing organism. We can separate them only by an effort of abstraction.

The distance apart of objects can be assessed with considerable accuracy from (*a*) their distance apart in the retinal image; (*b*) the kinaesthetic sensations of movements of the eyes and head made in focusing successive points; (*c*) the kinaesthetic sensations of movement made in stretching the hands and arms, walking from one point to another, etc. These various sensations are combined and integrated together to form a continuous plan or 'schema' of the relative positions and distances apart of objects. There is no discontinuity between the retinal images obtained at successive fixations. The gradual shading off of clearness in peripheral vision ensures that the field of view nowhere comes abruptly to an end. What has just been seen in the extra-foveal region is reproduced and combined with the foveal image into a consciously perceived object with an environmental context, as Auersperg (1939) points out. Thus perpetual slight shifts of fixation serve to fit together successive impressions of the different parts of the field into a perfectly continuous impression of the whole field of view. We have then no difficulty in locating within this field the exact position, to left or right, up or down, of any object, and in judging the distances of left-right and up-down. There is some evidence to show that such judgements depend on the accurate and efficient mechanism of successive fixations and eye movements. Thus Paterson and Zangwill (1944) and McFie, Piercy and Zangwill (1950) described certain cases with parieto-occipital lesions of the right hemisphere who were deficient in spatial orientation and understanding of spatial relations of the parts to the whole, and who also had very irregular and uncoordinated eye movements. They also cited cases of the same defect observed by previous writers.

From the above data, then, can be obtained accurate impressions of the relative localization of objects, that is to say, their size and arrangement related to one another. But the theory of 'local sign', originally expounded by Lotze to explain cutaneous localization, but later extended to visual phenomena, has been taken to indicate that there is a fixed and constant relationship between a particular point stimulated on the retina, and the relative and absolute spatial localization of the source of stimulation. According to Hering (1864), every point on the retina has a fixed and innate height and breadth 'value', from which the corresponding height and breadth 'value' of the external source of stimulation may be immediately inferred. We shall see from the data described below that although we do perceive with fair accuracy the orientation of objects with regard to the main co-ordinates of the visual field, yet the framework of these co-ordinates is by no means rigidly located in physical space. Neither is there an absolutely fixed and rigid correspondence between retinal distance and physical distance apart of the sources of stimulation. Indeed, Teuber and Bender (1949) have shown that in patients with occipital injuries the 'isotropic' structure of the visual field might be labile or distorted. In the normal individual, a shape appears the same size whatever the region of the retina upon which its image is formed. But in these patients there occurred distortions of contour, alterations of spatial position, and apparent increase of distance with reduction of apparent size. It seemed that unusual forces or stresses might be acting in the perceived field to make it appear narrower and deeper in the affected areas than in other parts. These effects were not fixed and persistent, as might have been expected had they been due to physical distortions of cortical structure, from injury. The effects were labile, and took time to develop. They seemed to result from some process of satiation, dependent possibly upon decreased or distorted gradients of excitability in the cortex. Normally, the gradient of excitability falls gradually and evenly in the visual cortex from the centre to the periphery. But in these cases, the gradient fell unevenly so that the central point of highest excitability was shifted to one side of the external stimulus field, and there was a corresponding distortion of the perceived field. This indicates that the correspondence in the normal individual between shape and size of the perceived field and those of the stimulus field is a functional and not a structural one.

In ordinary circumstances, we use the true or gravitational vertical co-ordinate, and the horizontal perpendicular to it, to provide a framework of orientation for our perceptual field. The vertical co-ordinate is the more fundamental, since in general it is given by the kinaesthetic and labyrinthine senses. Cases occur, however, in which the main co-ordinate of the perceived field is not in fact vertical, but is assumed to be so, and the remainder of the field is re-orientated about it. Thus the experiments of Gibson (1933) and of the author (1934b) showed that if an inclined line or shape was fixated for some considerable time, without any other surroundings being visible, there was a tendency for it to appear less tilted than originally. But if it was clearly perceived to be tilted, and this was formulated verbally, then the shape might acquire a 'tip character', and the tilt be even exaggerated (Radner and Gibson, 1935). When the tilt became diminished, then a vertical line exposed subsequently would tend to appear tilted in the opposite direction. Its absolute position in space was modified, while its orientation to the fixated line, which had taken on the function of the main co-ordinate of the field, remained constant. In some cases, the horizontal co-ordinate may operate in the same way. Koffka (1935) quotes the example of a building standing on a slightly sloping lawn; the building appeared to slope backwards, because the lawn was assumed to be horizontal. In the same way, the author, travelling on a steeply rising mountain railway, has observed a church situated on the opposite side of the valley to appear tilted, presumably because the railway track was assumed or felt to be horizontal. Koffka (1935) postulates the existence of a visual spatial framework constituted by the main co-ordinates of the visual field; this tends towards 'neutrality', i.e. the horizontal and vertical positions. The angles made by various objects with the framework remain 'invariant', i.e. are correctly perceived and retained. But in certain cases the framework may be tilted out of the vertical and horizontal without the observer being aware of the fact. He then perceives a compensatory tilt of the other objects in view, without realizing what has happened.

If, however, the apparent co-ordinates of the field diverge too greatly from the vertical and horizontal (the vertical as given by the gravitational senses), then the observer may be unable to compensate for this spontaneously. He will be aware of the divergence, and may feel greatly disorientated. Thus Wertheimer (1912) found that if the reflection of a room from an inclined mirror was viewed through a tube so that all other parts of the field were excluded, the whole room appeared tilted, and the objects in it topsy-turvy. At first the observer felt completely disorientated, but after a time the room regained its normal aspect. The observers of Gibson and Mowrer (1938), however, saw the tilt lessen with continued observation, but it did not disappear completely. They became accustomed to the fact that the main co-ordinates of the field were no longer horizontal and vertical, so that this fact no longer produced a feeling of disorientation.

An extensive series of experiments by Asch and Witkin (1948) and Witkin and Asch (1948) indicated that these effects differed in different observers. Their observers were first brought blindfolded into a room which they then viewed in a tilted mirror; a cardboard tube cut out direct vision of the room. Afterwards they were brought into the room with open eyes, and viewed it in the mirror with unrestricted vision. In both cases, an immediate estimate of the vertical was made, and it was found in general to approximate to the vertical as given by the scene in the tilted mirror, and not to the true vertical as given by the gravitational senses. But a few observers did set their estimate accurately to the true vertical. Some of the observers saw the mirror scene remaining upright, even when viewing it without the tube. Some were aware of a tilt, but felt that it was they who were tilted rather than the scene. And some saw the room as tilted at first, but reported that the tilt disappeared after a time. In a second experiment, an actually tilted room was used, the angle of tilt being 22 degrees. Again the observers were first brought into the room blindfolded, and afterwards with unrestricted vision. Individual differences similar to those of the first experiment appeared again, but there was a greater reliance on the visual co-ordinates when the only visible field was the tilted one. When in addition the observer was himself seated on a tilted chair, there was an even stronger tendency to rely on visual rather than on gravitational co-ordinates, especially if the body was tilted in a direction opposite to the direction of tilt of the room. But some observers found it possible even then deliberately to ignore the visual co-ordinates and to rely on the gravitational sense; whereas to others it was completely impossible, even after training and discussion of the effect, to eliminate the determining influence of the visual co-ordinates.

In another experiment, the observers viewed a luminous square frame tilted through 28 degrees in an otherwise dark room. In general, estimates of the vertical were affected to a less degree by this comparatively 'weak' visual framework, although its effect was greater when the body was tilted. But some observers became uncertain as to which was the top and which the sides of the frame. Then their errors of estimation became large and variable; they even lost their sense of position and location in the dark room. This feeling of complete disorientation never occurred with the stronger framework of the tilted room. These disorientated observers saw the luminous frame as upright most of the time. But other observers again saw the frame as tilted, and resisted its effects fairly well. Great doubt and hesitation were shown by observers who were strongly influenced by the visual framework.

Mann *et al.* (1949) found that, when the visual framework was comparatively 'weak', postural cues were more important than visual ones in determining the judgement of the postural vertical. Observers, displaced from the vertical position in a tilted chair, had first to set two parallel bright lines seen in a dark room to what appeared to be the horizontal position. Appreciable errors of judgement were made. The observers then had to set their own position to the vertical while viewing these lines which were tilted from the horizontal. They were able to do this with accuracy, in spite of the false visual cues to the horizontal. But these cues were much weaker than those which are provided by the normal visual framework.

In a further experiment, Witkin (1950) investigated the effect of altering the direction of the postural forces while keeping the visual framework horizontal and vertical. His observers were blindfolded and placed in a small cubicle which could be moved at various speeds round a circular track. The effect was of course that the observers obtained their postural cues from the resultant force of gravitation and the centrifugal force set up by rotation. They were usually aware that they were being moved, but were not at all clear as to the extent of the centrifugal movement—indeed, some observers thought that they were moving straight forwards. But they always felt that their bodies were being tilted. The blindfold having been removed, when the cubicle was illuminated the observers were able to set a rod in the horizontal and vertical position with considerable accuracy. But when the cubicle was in darkness and only the rod illuminated, the error of estimation was much greater, especially at high speeds of rotation; although even then the error was less than the angle of the resultant force. Again there were considerable individual differences. Some observers saw the walls of the cubicle as vertical, while others saw them as tilted. It was interesting to note that observers from the previous experiments of Witkin and Asch, who had relied more upon visual than upon postural factors, did the same in this experiment. And observers who previously relied mainly on the postural senses were more strongly influenced by them in this experiment. Nevertheless, there was a general tendency for the visual factors to predominate in estimation of the position of the vertical, and this tendency was operative even when the cubicle was in darkness. This result seems at first to conflict with that of Mann *et al.* But is should be noted that the postural cues are not distorted to anything like the same extent when the observer is merely tilted in a stationary position as when the resultant force acting on the body is at an angle with the vertical.

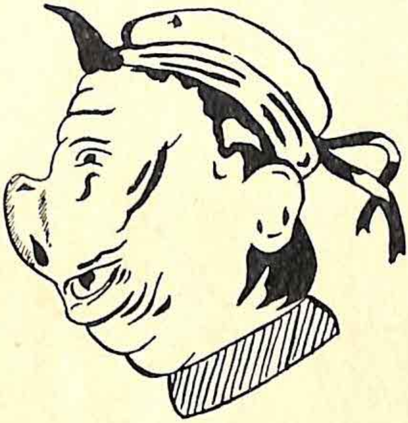


Fig. 17. The 'sailor' and the 'old man' figure.

Further evidence of the variability of perception when there is a conflict between the visually perceived framework and the position sense was found by Thouless (1947). He presented the reversible picture shown in Fig. 17 to adults and children aged five to eight-and-a-half years, first when they were in the upright position, and secondly when they viewed it with their heads between their legs. In the first case, the upper figure, the 'sailor', was seen as dominant. In the second, the majority of observers saw the 'old man' as dominant; that is to say, the figure corresponding to the inverted position of the head. But a few of the observers saw the 'sailor' as dominant in this position also; thus they were affected more by its relationship to the visually perceived framework than by its relationship to the position of the head. Of those who saw the 'head determined' face—the 'old man'—half saw it as upside down, indicating that they also took into account the visually perceived framework. Contrary to what might have been expected, the children showed much the same differences as did the adults.

It seems then that when there is conflict between the visually perceived co-ordinates and the gravitational sense, the resulting perceptions and behaviour of the observer are partly an individual matter, although they also depend on the 'strength' and inclusiveness of the visual framework, and the normality of direction of the gravitational senses. But perception and behaviour are also affected by the length of time to which the observer is exposed to the conflicting sensory data, and to his behaviour during this period. Thus Stratton (1897) and Ewert (1930) observed the effects of wearing continuously prismatic lenses which completely inverted the field. At first the observers felt completely disorientated; their movements were uncoordinated, and they could not localize objects correctly. After a time, however, they adjusted themselves, disorientation was no longer experienced, and movements, especially those involving overt spatial orientation and localization, became more accurate and co-ordinated. But it was not a case of the visual field ceasing to appear inverted; but that the observers acquired a new spatial scheme in which, for instance, kinaesthetic impressions of upward movement correspond to visual impressions of downward movement, etc.

Again, Brown (1928) found that observers, who for short periods wore over their eyes prisms which inclined the field through 75 degrees, improved considerably in a test of star-drawing and in performance on a pursuitmeter. But they showed little improvement on a test of steadiness, or in their ability to adjust two discs to be at the same distance as a third disc. Thus disorientation affected depth perception as well, a fact also noted by Ewert. An observer who wore the prisms in Brown's experiment continuously for a week improved on all four tests, however, and became more or less accustomed to the disorientation of the field. Thus the important factors are length of time to adjust, and an active effort to do so. The reorientation seems to develop piecemeal, more rapidly in situations in which it is overtly practised.

When the visual framework is almost completely absent, that is, if an observer sees a single point or line of light in a dark room, there will tend to be a loss of orientation rather than a confusion of orientation. Thus G. E. Müller (1917) found that if an observer in a darkened room viewed a vertical bright line with his head tilted, then the line might become increasingly more oblique. Witkin and Asch (1948) also found that observers could accurately adjust a luminous rod to the vertical in a dark room as long as the body was upright, but became less accurate if the body, or even the head, were tilted. Again individual differences were considerable, and the judgements of a single observer might vary greatly from time to time. A similar loss of orientation appears in conjunction with the so-called 'autokinetic movement' of a point of light viewed in a dark room. There is no visual framework within which the light can be anchored; and it may appear to wander about at random over quite large distances. But even a comparatively 'weak' framework, such as was produced by the previous fixation for two minutes of a luminous semicircle, was found by Crutchfield and Edwards (1949) to reduce the autokinetic movement considerably.

Another type of disorientation was demonstrated by Duncker (1929) with two lights in a dark room, one of which moved while the other remained stationary. The normal spatial framework was obscured; and it appeared that in general whichever of the two objects was perceived as providing a framework for the other appeared to remain stationary, while the other appeared to move. If, however, they were similar objects, other things being equal, both appeared to move, in opposite directions. The amount of movement was 'invariant', whether one or both objects moved. Fixation of one of the objects, whether actually moving or not, made this one appear to move, presumably since the fixated object took on the function of 'figure'. The other object then functioned as 'ground', or frame of reference, and appeared to remain stationary. Oppenheimer (1934) also found that the object of greater intensity tended to become the framework for the one of less intensity, and therefore to remain stationary. When the object which was not actually moving was the one which appeared to move, the observer at the same time experienced a movement of his own eyes. Duncker (1929) also found that when a moving rectangle enclosed a stationary point fixated by the observer from a comparatively short distance, then the observer saw the point as moving and the rectangle as stationary and experienced the sensation of being moved to and fro, sometimes to the extent of dizziness. But if some part of the room surroundings were visible, to provide a steady visual framework, this did not occur.

Again, in certain situations the labyrinthine and kinaesthetic sensation are not accurately co-ordinated with each other, or with the visual impressions, although the visual framework retains its normal orientation. Examples of this occur on board ship in a rough sea; while flying; and while being rotated passively on a rotating chair. On board ship, the gravitational forces are co-ordinated with the visual framework, but the kinaesthetic sensations arising from the adjustment of the position of the body to the movements of the ship oscillate to and fro about the vertical position. Disorientation, giddiness, and vomiting may result. In flying, there may be an additional conflict between the gravitational forces and the centrifugal forces set up by the curving movements of the aircraft. Thus it is not uncommon for the pilot to set the position of his aircraft by the resultant of those forces, and to fly in a tilted position. It may then appear to him that the horizon itself is tilted, while he is horizontal. Similar impressions were recorded by Gibson and Mowrer (1938) from the reports of motor cyclists riding on the 'Wall of Death'—a large barrel-shaped structure with vertical sides round which they rode at high speed in an almost horizontal position. Here of course the visual setting was not at all prominent. It seemed to them that they were riding in a vertical position along an endless horizontal track.

The work of Graybiel *et al.* (1946) has shown that if an observer is rapidly rotated while fixating a stationary light in a dark room, the light appears at first to move rapidly in the direction of the turn; when a steady speed is attained, the light appears to come to rest; and as the observer slows down, the light appears to move rapidly in the opposite direction. If the light moves along a circular path in the same direction as that of the observer's rotation, it will appear not to move but to change position; as his speed increases, it will appear to displace more rapidly until the observer feels himself to be stationary while the light rotates round him; and as he slows down, the light rushes rapidly past him in the opposite direction.

From this discussion, it appears that our normal accurate sense of spatial orientation and our accuracy of movement are dependent upon the maintenance of the habitual relationship of the main co-ordinates of the visually perceived field with both kinaesthetic and labyrinthine sensations (the latter producing together the vertical gravitational sense). All objects in the field are located by means of their relationship to these visual co-ordinates, which thus constitutes a visual framework of reference for their position. The individual's feeling of stability depends upon the stability of this framework. If some part of the sensory data which constitute the framework is impaired, or conflicts with some other part, stability is so far affected that the individual is disorientated, that is to say, he loses his usual impression of an exact and enduring position of his body in space.

(2) THE THREE-DIMENSIONAL FIELD

But in ordinary everyday life we are aware of the positions of objects in three-dimensional space. We localize them with regard to distance, as well as to left or right, up or down. It is a good deal harder to explain the accuracy of three-dimensional localization than of two-dimensional. We perceive immediately that objects are at various distances away, and we can immediately assess these distances relatively, and even judge them roughly in terms of, for instance, the distance we should have to stretch our arms, or walk, in order to reach them. As we shall see below, our perception is at fault only when extreme accuracy of localization is required, or when distances are so great that we cannot perceive any continuous succession of objects between ourselves and the horizon.

So spontaneous is the impression of three-dimensionality that it may occur even in viewing perfectly plane fields. The emergence of the 'figure' from the 'ground' suggests the appearance of at least two planes one in front of the other. Drawings and paintings in 'perspective' give a clearer or more graded appearance of three-dimensionality. Simple outline drawings such as the Necker cube, the staircase figure, and the passage figure can give a strong impression of relief, which may be reversible in cases where the outlines can suggest either protuberance or relief (see Fig. 26, p. 207). Here we are again confronted by the tendency described in Chapter III to see drawings immediately as representations of solid objects. Koffka considers that the appearance of three-dimensionality in figures such as the Necker cube is in accordance with the Law of Prägnanz, since the three-dimensional percept possesses greater 'goodness'—in particular, more symmetry—than would a two-dimensional percept.

Yet Michotte (1950a) has pointed out that of the two drawings shown in Fig. 18, the first appears three-dimensional and the second

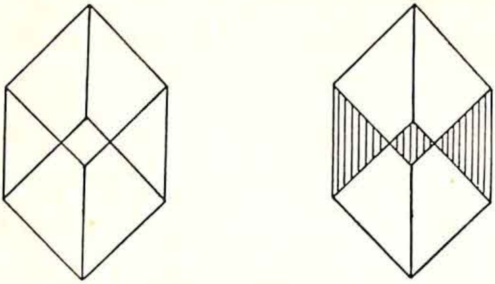


Fig. 18. Three- and two-dimensional figures.

does not. Both are equally symmetrical; the second is organized as a group of squares and trapezoids forming a hexagon, but the contour of the first is seen, not as a hexagon, but as that of a three-dimensional cube. Hence the three-dimensional impression is a function of the particular organization of the field. Moreover, it is possible to estimate quantitatively the three-dimensional depth of an outline drawing such as that in Fig. 18. And this can be done with as much accuracy as with a 'real' three-dimensional object constructed out of wire (the wire forms the contour of a cube) (Michotte, 1948). But at the same time the outline drawing can readily be differentiated from a 'real' object. We shall discuss the nature of this 'reality' more fully in Chapter IX.

But into our normal everyday experience of the perception of depth and distance a large number of different factors appear to enter. There is of course no immediate retinal concomitant of three-dimensional distance to correspond to the retinal representation of two-dimensional distance. A vast amount of work has been devoted to the analysis of the factors which are involved in three-dimensional perception. These factors are numerous, and they operate differently in different types of phenomenal experience. The immediate impressions of space, distance, and depth or relief, and the more accurate judgements of relative or absolute distance of objects, may all bring into play the same sensory and ideational factors. But it is by no means certain that these factors operate to the same extent or in the same manner in these different types of experience. This may explain some of the disagreement that has occurred between different experimenters. We can merely indicate the various factors and the parts which they seem to play.

The following factors have been found to enter at some time or other into normal three-dimensional spatial perception:

(1) Kinaesthetic sensations produced by convergent and divergent eye movements. These operate accurately only up to distances of about two metres.

(2) Kinaesthetic sensations of accommodatory movements, which operate up to a similar distance.

(3) Visual sensations of retinal disparity, based upon the fact that parts of the field at different distances than the fixation point of the two eyes subtend different angles at the eye (binocular parallax), and are focused upon non-corresponding points of the retina; they thus tend to appear unlike, disparate, or double. These sensations also only operate in binocular vision, but up to greater distances.

(4) Visual sensations of parallactic movement, i.e. of the apparent movement of objects relative to the observer and to one another when the observer is himself moving in space.

(5) Relative sizes of the retinal images of different parts of the field.

(6) Relative brightness, clearness, and colour saturation of different parts of the field.

(7) Perspective effects, overlapping planes, shadows, and the general structural arrangement of the field.

(8) Previous knowledge of and familiarity with the spatial arrangement of the field.

Much of the early work of Wundt (1862), Arrer (1898), Hillebrand (1894), Dixon (1895), and Baird (1903) was aimed at comparing the relative importance of *convergence*, *accommodation*, and *disparity* sensations. Wundt and Arrer used black threads seen through a darkened tube against a white ground. Hillebrand, Dixon, and Baird considered that size comparison might function with such an arrangement, and therefore used the edges of black screens as test objects. Absolute distance localization was measured by requiring the observer to report if a thread or screen appeared to move towards or away from him. This estimate was very uncertain in binocular vision, and in monocular vision it was found to be almost random guesswork, unless, as in Baird's experiments (1903), the observer was allowed to see the screen at rest before it began to move. Relative localization was measured by requiring the observer to say which of two threads, or of two screens, exposed one immediately after the other, appeared to be nearer or farther. This was done very much more accurately in binocular than in monocular vision. From these results it was concluded that the predominant part in binocular vision was played by the kinaesthetic sensations of tension and change of tension in the extra-ocular muscles. Baird concluded that a corresponding part was played by the accommodatory sensations in monocular vision, in contradiction to Hillebrand (1894), who denied them any function at all, and considered, on the basis of another experiment (described on p. 102) that monocular distance estimates were based on size comparisons.

Certain comments upon these experiments are apposite. Some feature of the retinal sensory pattern must have been required to act as a stimulus for the reflex convergent and accommodatory movements. In binocular vision this might have been the constant shift towards disparity of the moving object (with absolute distance estimation); and the disparity between the two objects or the lack of fusion in glancing from one to the other (with relative distance estimation). Or it might have been the blurring which occurred whenever accommodation was not correctly adjusted. In monocular vision only the second factor could have operated. But it is quite clear that there must have been some change in the pattern of retinal stimulation for the moving objects, and some difference between the stimulations for the two objects, which may have been directly and immediately perceived by the observer as a cue to estimation of change in absolute or relative distance. It seems improbable that lack of fusion and double images were of great importance. In normal vision we are hardly ever aware of the double images produced by the large range of non-corresponding retinal stimulations, and even in these experiments they were rarely reported. Not only are they difficult to perceive directly, but also they cannot provide an accurately graded stimulus pattern for the reflex convergent movements. The actual fixation point reached on the retina after binocular convergent movements often varies quite considerably on different occasions. Clark (1936) has shown that impressions falling on any point within 1 degree to 1·5 degrees of the fovea produce a single fused binocular image. If then the angle of convergence necessary to produce fused binocular images of an object at a given distance varies from time to time, there can be no fixed relationship between distance and degree of convergence tension, whether the distances and tensions are absolute or relative. We could not even be certain that equality of convergence tension would indicate equality of distance.

But there appears to be a much closer correspondence between reflex convergent and accommodatory movements. We might then suppose, as Arrer (1898) postulated, that distance was estimated from sensations of convergence, the convergent movements occurring in conjunction with accommodatory movements stimulated by lack of clearness in the retinal pattern. The superiority of binocular to monocular estimates of distance would then presumably be explained by saying that sensations of convergent and accommodatory tensions together can be apprehended with greater ease and accuracy than can sensations of accommodation alone. But some observations of the author (1937a) seem to disprove this theory conclusively. In this experiment, a moving object was viewed through prisms which deviated the two binocular fields outwards, and was stopped by the observer when it appeared equidistant with a stationary object viewed normally, without prism deviation. Thus if the binocular fusion sensations alone were followed, the position at which the moving object was stopped would bear a certain relationship to the distance of the stationary object, which relationship could be calculated from the deviation produced by the prisms. If the binocular sensations were ignored, the distance of the moving object could be equated to that of the stationary object on the basis of the remaining sensory and perceptual data, including the accommodatory sensations. It was found that almost all the observers adopted the first procedure, and stopped the object at such a position that there was no disparity or inequality of convergence between it and the stationary object; moreover their estimates were on the whole accurate and consistent. Clearly, though, accommodation must have been quite inaccurate, and in point of fact one of the objects (usually the moving one) always looked blurred. This then shows that in binocular vision accurate and consistent estimates of apparent equality of distance could be made without any assistance from accommodatory sensations, and indeed in direct conflict with these. This does not, however, dispose of the possible importance of accommodatory sensations in monocular vision, a question to which we shall return later.

We must conclude, then, that in so far as comparison and equalization of distance can be made in binocular vision in the absence of all other sensory and perceptual data, as in the experiments described on p. 94, or in conflict with them, as in the author's experiments, they must be based solely and immediately upon *retinal im-*

pressions of disparity—and indeed this was the theory of Hering (1864, 1865). Thus the characteristic 'flatness of a scene viewed monocularly probably results from the fact that the sensations of disparity, upon which the actual perception of depth is based, have been eliminated. We must then examine more closely the nature of this immediate experience of disparity. We have shown that it is an experience different in kind from that of lack of fusion. Stereoscopic experiments show that it also differs from the experience of fusion of identical binocular images, and that, under certain limiting conditions, it is essentially connected with immediate perception of depth or recession. There is then a certain degree of unlikeness or 'non-correspondence' falling short of that which gives rise to double images, of all parts of the binocular retinal images except the parts equidistant with the central fixation point;[1] which unlikeness is seen directly and immediately as a non-equidistance of all those parts with the fixation point. This unlikeness is based upon the fact that the spatial relationship between the fixation point and the other retinal points stimulated is different for the two eyes. Hence the term 'non-corresponding' points for those other retinal points. But it cannot be too strongly emphasized that there is no exact mathematical relationship between the retinal distribution of the non-corresponding points and the degree of depth or distance observed. The 'Allée' experiments of Poppelreuter (1911) and Blumenfeld (1913) have shown that equal amounts of disparity (equal differences of visual angle) do not correspond to equal amounts of increase in apparent depth. Moreover, the relationship is liable to modification by suitable manipulation of the structure of the field, and in some cases may be destroyed or reversed.

These effects have been explained by Koffka (1930) in terms of field organization. He postulates firstly that for perception by the two eyes of a single point in the same plane as the fixation point, two corresponding points must be stimulated *in the same manner*.

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[1] These parts are equidistant with the fixation point only when they are contiguous with it. The horopter, which is the locus of points the images of which fall on corresponding points of the retina, is actually sloped and curved as it recedes from the fixation point. Its exact form, however, is not germane to the discussion in this book.

Whereas, when two disparate points are stimulated in the same manner, there will not be the perception of a single point, or not in the same plane as the fixation point. Where disparity of stimulation occurs, there will be a stress in the field. When disparity is not too great, this stress results in the unification in depth of the two disparate points, and a single point will be seen either nearer or further than the fixation point. The forces producing the stress depend on the organization of the total field. Thus, according to Koffka, the following phenomenon may be observed: two pairs of equidistant parallel lines are presented, one to each eye, one member of each pair being dotted in such a way that the dots in the left-hand field correspond to the spaces in the line of the right-hand field. Then the two dotted lines combine in binocular vision to form a full line. And if one dotted line is moved to the right, the other moves with it, so that the full line is preserved, but recedes behind the plane of the two superimposed full lines. Thus the interaction which produces the stereoscopic effect depends on the fact that the two dotted lines become organized together. Again, Koffka (1930) quotes the results of Lau (1925), who found that if two lines are thrown on corresponding retinal points, but each is given a different apparent distortion by some background pattern, a stereoscopic effect is produced.

Again, the forces producing the stress may be disorganized by injuries to the cerebral cortex, as the work of Bender and Teuber (1948) has shown. One of their patients was unable to fuse stereoscopic slides in the normal way, because the left lower quadrant of his perceived field was distorted by injury in such a way that objects in it appeared relatively smaller and further away than objects in other parts of the field. There was no real exaggeration of disparity, but the apparent increase was sufficient to prevent ordinary stereoscopic fusion.

In normal circumstances, then, it may be deduced that in general, though not invariably, the appearance of non-equidistance is produced by the stimulation of non-corresponding points. According to the theory of Hering (1864), the parts of the field which stimulate the nasal halves of the retinae are seen immediately and directly as farther than the fixation point, and those stimulating the temporal halves as nearer. The experiments of Wundt and others (see p. 94) seem to show that the estimate of 'nearer' and 'farther' can sometimes be made with fair efficiency from these data. But certain other experiments (see p. 100) show that this is not always so.

There seems little doubt, however, that the perception of equidistance and non-equidistance is immediate and sometimes extremely accurate when based upon impressions of disparity alone. Thus in the classical experiment of Dove (1841), stereoscopic relief was observed when the field was momentarily illuminated by means of an electric spark. Though the amount and direction of the depth effect may have been mediated in such a case by previous knowledge as to the distribution of the field, it is unlikely that the actual direct perception of the depth effect was based on anything but the instantaneous impression of disparity. Again, if two pairs of dots are presented stereoscopically, one to each eye, one pair being slightly farther apart than the other, the dots will fuse so that only a single pair is perceived, with one of the dots situated in front of the other. Smith (1946) showed that when two points of light were flashed for one-sixtieth of a second sometimes nearer to one another than the fixation mark on to which the eye was directed, and sometimes farther apart, the binocular impression obtained in general appeared to be nearer than the fixation mark in the first case, and farther away in the second. And pairs of dots, at different distances apart in a plane at right angles to the line of sight, could be fused to appear as single dots at different distances from the observer; and the distances could be compared with considerable accuracy when the period of exposure was only one-sixtieth of a second (Smith, 1949). Again, Pi Suner (1947) demonstrated the possibility of obtaining stereoscopic impressions by projecting the right and left eye images of a field in rapid alternation on the two eyes.

In stereoscopic instruments, the ability to perceive non-equidistance of two points and to produce equidistance by adjustment of the instrument has been refined to such a degree that a difference of angle of parallax (angle subtended at the object by the two eyes) between the two objects of as little as 4 seconds can be discriminated. To give the maximum degree of acuity, however, the angular separation of the two objects compared in a direction at right angles to the line of sight must be very small. In stereoscopic instruments, the points to be compared are so close that they can be viewed simultaneously, one by direct, the other by indirect, vision without change of fixation. This is of course very frequently impossible in normal perception, and a period of time, during which occur rotatory eye movements, must intervene during the estimation of disparity. Hence the distance threshold is considerably increased.

There seems to be some evidence to show that the observer must be suitably 'set' or prepared to perceive depth effects based on disparity alone. Stereoscopic relief is not always seen immediately by unpractised observers. Karpinska (1910), repeating the Dove experiment, found that if the observer did not know before the exposure whether the stereogram would be flat or stereoscopic, he frequently did not see any stereoscopic relief when it should have been perceived. Bonaventura (1931), again, states that if angular separation is isolated from all structural differences of size, form, brightness, etc., stereoscopic acuity is largely destroyed. Again, in the use of stereoscopic instruments, only highly trained observers can under favourable conditions reach the high degree of precision mentioned above. Thus, although we may not agree with Benussi (1925), Lavelle (1921), and others that perception of stereoscopic relief is necessarily a slowly developing process requiring efforts of attention; yet it does seem possible that if relief is to be seen immediately, the observer must first be correctly orientated to perceive it.

We must then recognize that (*a*) disparity sensations alone can only give rise to a perception of non-equidistance of certain parts; (*b*) definite impressions of 'nearer' and 'farther', and the degree of 'nearness' and 'farness' will be obtained with certainty only when certain other perceptual data can also be employed; kinaesthetic sensations of different degrees of convergence, or of changes in convergence, are probably of great importance also in this respect, particularly over near distances; (*c*) even perception of non-equidistance may be destroyed if the impression of disparity conflicts with other perceptual impressions (see p. 108); (*d*) binocular disparity operates only within a comparatively limited distance, of the order of 110 metres. For objects at greater distances, the lines of regard of the two eyes are parallel, and there is no disparity between binocular images.

We shall now proceed to examine the other types of data which it has been suggested may assist binocular distance perception, and be responsible for such perception of distance as is possible in monocular vision when disparity is eliminated. We have emphasized the fact that the perception of depth from sensations of disparity is essentially an immediate process; the observer is quite unaware of the nature of the differences between the binocular retinal images, and could not analyse their phenomenal nature. The same would apply also to sensations of convergence and accommodation, if these play any part in distance perception. When an observer employs any of these data to equalize the distances of two objects, he can as a rule merely report that 'one object looked as if it were in the same straight line as the other' or 'immediately under the other'. In general, the use of other types of data is more immediately open to introspection. We must not conclude that such a use is always secondary and deliberate, involving 'inspection' (see p. 219) and even processes of judgement; for it is possible to find cases in which data of this kind have been employed spontaneously, as immediate and unlearned perceptual processes.

Examples of such immediate processes are provided by the phenomena of *apparent size* and *change of size*. Even in binocular vision, variation in size of the retinal image with change of distance may play an important part. Bernyer, Durup and Piéron (1939) carried out some ingenious experiments in which objects appeared to diminish in size while convergence increased, and *vice versa*; within certain limits they found that judgements of distance were determined by the apparent size rather than by the degree of convergence. Pouillard (1933) has also shown that in the binocular (but non-disparate) perception of two figures of identical form but different magnitude, the larger was seen as nearer than the smaller in 90 per cent of cases. Carr (1935) quotes results obtained by Duncan which showed that when two light boxes of different sizes were exposed, presumably with surroundings concealed, the larger box was consistently placed farther away from the observer in order that he should perceive it as equidistant with the smaller. Ames (1946a) states that if the projected image of a familiar object such as a playing-card is increased in size while viewed monocularly, it will appear to come nearer to the observer; if decreased, it will appear to recede. This phenomenon appears most clearly with objects of known size. Hillebrand considered that in monocular distance perception this factor of size was of paramount importance. Hillebrand (1894) found that if the illuminated aperture of an iris diaphragm, viewed monocularly with all other surroundings concealed, was gradually increased in size, it appeared to move forwards, even though it was actually being moved backwards at the time: thus the apparent size was of more importance than the change of accommodation. Calvarézo (1934) found that if two forms of the same shape but different size were exposed stroboscopically, the observer saw one form which changed its distance. This phenomenon was dependent on the observer's impression that he saw only a single form, and that it showed optimal apparent movement. Thus when the observer was 'set' for constancy of actual size of the object, he saw a change in size of the retinal image as constancy of apparent size with corresponding change of distance (for discussion of the phenomenon of size constancy see pp. 122–6). Lastly, Weymouth and Hirsch (1944) found that monocular distance discrimination depended chiefly on angular size, and thus the discrimination threshold was directly proportional to absolute distance.

✓ Further evidence has recently been brought to light as to the relationship of *parallactic movement* to changes in the size of the retinal image with changes of distance. Now if the observer moves forward in space, the retinal image of the field in front of him will expand, the retinal images of particular objects becoming larger; the image of the field behind him will contract; and the images of the fields on either side of him will be correspondingly deformed. The nearer objects will show a greater degree of expansion and contraction than the farther ones; and the horizon will not change at all. But this contraction and expansion of the retinal images will be perceived as change of distance with movement, not as deformation of the field.[1] Consequently, it is possible to obtain some idea of the distance of objects by the relative amount or speed of expansion as the observer moves, provided that he knows his own speed; on the other hand, if he can perceive the distance of objects from other cues, he can estimate his own speed of movement. And from the gradient of change of shape, he can estimate the gradient of change of speed. These observations have been shown by Gibson and Glaser (1947) to be of great value to pilots in estimating the landing direction and speed of aircraft.

But we must also take into account corresponding changes, with change of distance, of the *clearness*, *brightness*, and *colour* of objects. For instance, it is well known that a general diminution of brightness, colour saturation, clearness and definiteness of contours, detail, and surface structure of very distant objects is produced by the intervening atmospheric layers. This phenomenon is known as 'aerial perspective', and it is important in producing the impression of great distance, though estimates of distance based upon it are often liable to error when the observer is unable to allow for the effects of variation in the clearness or haziness of the atmosphere. According to Krauss (1928) the phenomenon may be simulated by continuously changing the intensity of the general illumination; the illuminated spaces will then appear to shrink and expand accordingly.

In the perception and estimation of distance of objects within comparatively enclosed spaces, and especially indoors, the distance from the source or sources of illumination and the distribution of light and shadow play a very large part. But for the observer to be able to perceive those differences in brightness which are due to differences in distance from the sources of light, he must also be able to discriminate between the effects which are due to the general illumination, and those resulting from the intrinsic brightness or whiteness of the surface. This he can do partly by means of his perception of the organization of the total field, in a manner which will be discussed more fully in the next chapter. Also, as Katz (1935) has pointed out, he will take into account the structural relations within the surface, particularly of its minute surface structure or 'microstructure'. For if the surface is viewed through the hole in a screen (placed at some distance from the observer), the surface structure disappears, probably because the eye is now accommodated upon the screen and not upon the surface. As a consequence, the surface of the object is no longer perceived as surface but rather as a vague filmy mass of colour with no definite localization. And if the surface actually possesses relief, the appearance of shadow and relief is destroyed, leaving the appearance of patches of different colours in the same plane as the unshadowed part of the surface. Thus Wagner (1941) showed that if objects are enclosed in a hollow sphere with a luminescent wall, they will of course, be entirely lacking in shadows. The appearance of spatial voluminosity of objects is lost; corners and edges of a cube are seen indistinctly, and a ball appears completely flat. Again, Lauenstein (1938) found that changing the source, intensity, and direction of illumination of solid objects and bas-reliefs changed their appearance, and the impression of 'corporateness' given by them. According to Fieandt (1938) the appearance of bulges or dents in a surface can be produced by changes in apparent direction of illumination. Although on the whole there is a tendency to see convexity rather than concavity—presumably since most solid objects have convex rather than concave surfaces—illumination from above could change this impression.

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[1] We do not perceive this parallactic movement as such, because we normally assume the stability of the spatial framework. If the normality of the framework is destroyed by wearing aniseikonic lenses, then parallactic movement may become so impressive that, for instance, the window frames of a room will appear to move about in space when the observer moves his head.

Clearly, then, perception of depth and solidity are closely connected to differences of colour and brightness of the different parts of objects. But the perception of distance itself is also related to clearness, brightness, and colour saturation, which decrease as objects recede from the observer. Thus Johns and Sumner (1948) found that observers, required to equate the apparent distances of chromatic and neutral coloured papers, tended to see the brighter colours, white and yellow, as relatively nearer than the neutral grey; and the darker colours, green, blue, and black, as relatively farther than the neutral grey. Again a decrease in clearness is relatively easy to perceive in a strongly patterned surface, or one possessing a clearly perceptible micro-structure (such as grained wood or roughly surfaced cloth), the interstices of the pattern becoming smaller and less defined as the surface recedes. Change of distance can thus be inferred from change of pattern. Thus the author (1937a) showed that in monocular vision estimates of the distance of plain white surfaces were less accurate and reliable than estimates of the distance of mottled grey paper, which presented an appreciable surface structure to the observer.

We also have evidence of a phenomenon which seems to function in close conjunction with clearness of surface structure, namely, apparent 'colouredness' or strength of saturation of colour. This appears with neutral, as well as with chromatic, colour. With a uniform general illumination, objects appear as they recede from the observer to lose their colour, to become less strongly coloured, to look lighter in colour. This phenomenon seems to link up albedo, retinal brightness[1] and apparent distance, as apparent size links up actual size, retinal size and apparent distance. Thus the author (1937a) found that there was a tendency to see the lighter greys of a series of papers of varying albedo as farther away than the darker greys, although the intensity of illumination was constant, and the observers were aware that there was a variation of albedo. Phenomenally, the increased lightness may appear very much like a loss of saturation of neutral colour closely related to decreasing clearness of micro-structure, and also, of course, dependent upon the accurate accommodation of the eye to the surface. Similar results were obtained by Münster (1941). He showed that if two equidistant bright surfaces were presented to the two eyes separately, and a dark filter interposed between one eye and the surface perceived by that eye, then this surface appeared farther away than the surface perceived by the other eye. The results of Johns and Sumner (1948) quoted above give additional evidence. Again, Duncan (see Carr, 1935) found that if two light boxes of different brightness were seen in binocular vision, in general the brighter appeared nearer, although the ratio of apparent brightness varied at different distances of the two boxes, and not all the observers obtained the effect. And Ames (1946a) states that if the brightness of the projected image of a familiar object seen in monocular vision is decreased, it will appear to recede (and vice versa); though the effect is less striking than that obtained with change of size. But it is nevertheless clear that in some cases differences of brightness are actually seen as differences of distance.

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[1] A more accurate term than 'retinal brightness' would be 'reduction value' (see p. 133) or 'stimulus character' (see p. 120).

Kompaneisky (1939) found that there is a change of hue, as well as a decrease of colour saturation, with increase of distance. All colours, he found, tended to approach one of two wave-lengths: one at about 540 mμ (red), the other between 485 and 500 mμ (blue-green): thus receding from the orange, yellow, and green regions. This change presumably accounts for the bluish purple tinge so characteristic of distant hills.

All the various factors we have described contribute together to produce spatial impressions and enable us to judge distances of objects. They are, moreover, integrated with one another and with the *perception of the surroundings*. Thus not only disparity, size, brightness, etc., of test objects are observed, but also the relationship between these and the disparity, size, brightness, etc., of the surroundings, and their gradual modification with distance in linear and aerial perspective. Schriever (1924) showed the importance of *linear perspective*, shadow effects and overlapping of certain parts of the field, in the stereoscopic vision of photographs of solid objects. An alteration in disparity did not produce an alteration in depth perception provided the above three factors, and especially that of overlapping, were kept constant. Indeed, a perception of the surroundings and the general setting of an object seems to be almost essential to its accurate localization. Bourdon (1902) and Jastrow (1910) found that it was impossible, with the head held stationary (to eliminate sensations of parallactic movement) to localize a bright spot in a completely dark room of unknown dimensions, even in binocular vision. But if only a slight gleam of light was introduced giving a vague idea as to the nature of the surroundings, localization became possible. An experiment by Jaensch (1911) showed that relative localization might also be considerably affected. If an observer was presented with three vertical threads, the middle one of which was nearer to him than the others, he perceived a wedge-shaped structure protruding towards him. If the threads were replaced by luminous wires in a dark room, the wedge was greatly reduced and might disappear altogether, the wires appearing to lie in one plane. Again, in some experiments of the author (1937a) it was shown that the equalization of distance of two white screens, each with a black dot upon it, was sometimes more accurate in monocular vision when the surroundings were partly visible than in binocular vision when they were obscured. Several observers had considerable difficulty in apprehending directly the degree of disparity between the two test objects when unassisted by any perception of the intermediate degrees of disparity of the surroundings. But it was reported that in the monocular observations with surroundings visible, the correct relationship of object to surroundings was often difficult to apprehend because the size relationships of the two test objects to each other and to their surroundings were unknown. This agrees with the statement made above that size relationships are apprehended not so much as separate entities, but rather as forming part of the pattern of the whole setting. In the distorted room of Ames (1946a), for instance, the relationship of walls, floor, door, and ceiling may appear normal, if viewed monocularly through a reduction screen, although their angular orientation to each other is completely distorted; and the apparent sizes of objects introduced into it will be in agreement with their apparent distances as determined by the apparently normal orientation of the sides of the room.

The closer the relationship between objects and surroundings, and the greater the continuity between them, the easier and more accurate will be estimation and localization. This continuity may depend in part on spatial contiguity. In the experiments of the author (1937a) the observers found it very difficult to decide within a short period of exposure which of two test objects, seen binocularly, was in front of the other, although they could tell that the objects were not equidistant. There was insufficient time to relate the objects to their surroundings, which were not in close contiguity, and hence to localize the objects accurately. This of course confirms the statement made on p. 100 that the sensations of disparity between two objects cannot always determine which of the two is nearer and which farther.

The importance of *structural continuity*, apart from spatial contiguity, of the spatial pattern within which the test objects are included, is shown by various experiments. Pouillard (1933) found that estimation and comparison of depth and distance in the stereoscope were made much easier if intermediate levels and receding perspective lines were also included in the stereograms. Kopferman (1930) showed that disparity sensations might be altogether ignored if they conflicted with configurational factors. In his experiments, different parts of a line figure were drawn on glass slides, which were presented one behind the other at different distances from the observer, in such a way that the parts of the pattern appeared contiguous. Binocular vision was used. But if the parts of the pattern formed a connected whole, as for instance those shown in Fig. 19 *a*, the pattern was seen as a single two-dimensional whole all situated in one plane. The parts in Fig. 19 *b* again were seen as a single three-dimensional whole. But if the parts did not form a single well-articulated whole, as for instance those in Fig. 19 *c*, the observer saw them as disconnected parts situated in different planes. Thus the three-dimensionality of Fig. 19 *b* was dependent upon its structural

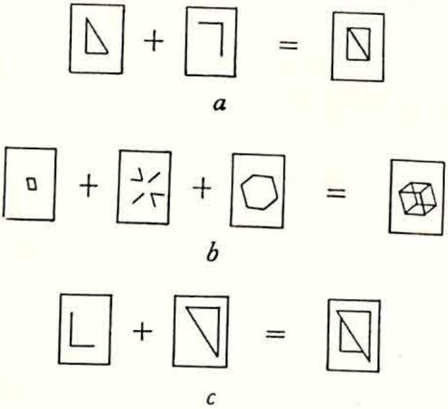

Fig. 19. The effect of structural continuity upon three-dimensional perception.

relationships, not upon the actual disparity of its constituent parts. Again, Schlosberg (1941) states that if a single photograph is viewed monocularly through a lens of the same focal length as that of the camera with which it was photographed, a plastic or depth effect is obtained which is almost as good as that obtained with stereoscopic pictures. This effect seems to be due partly to the removal of cues to the perception of flatness normally given by the margin of the picture and its surrounding objects; though also in part by the correct accommodation, apparent size, and linear perspective introduced by the refraction of the lens.

However, accurate relative localization is probably impossible merely from the general structural setting, when disparity is eliminated, as in monocular vision. The author's experiments (1937a) showed that reduced cues from surroundings which were adequate to produce equalization of distance in binocular vision were quite inadequate for that purpose in monocular vision. In the latter case, distance equalization was inconsistent and unreliable, and accompanied by great uncertainty and confusion on the part of the observer. Even with far distant objects, for which disparity is comparatively ineffective, it seems probable that the linear perspective effects are dependent upon the structural gradation of the near distance which results from a proper co-ordination of binocular perceptual effects. When distance increases and disparity becomes less clearly perceptible the three-dimensional appearance is nevertheless continued through the perception of perspective and size, colour, and brightness relationships.

Finally, there seems to be little doubt that in all familiar spatial settings the observer's *previous knowledge* as to the nature of the spatial surroundings exerts considerable influence upon the spatial relationships which he actually perceives. In comparatively artificial experimental conditions, familiarity with the spatial setting may be a matter of some importance. Thus, if two stereoscopic slides representing landscape scenes or familiar objects are reversed in the stereoscope, in general the observer perceives normal and not reversed perspective (Eaton, 1919). Edridge-Green (1920) found that a normal stereoscopic impression was obtained if the left-hand part of the left member of a pair of stereoscopic photographs (of familiar objects) was cut off and attached to a piece of white paper, and similarly the right-hand part of the right member; and the two viewed in a stereoscope in their correct positions with no overlapping of the photographs. In this case of course there were no binocularly disparate retinal images, but only a right-eye view of the right part of the picture, and a left-eye view of the left part. Again, Ames (1946a) points out that the distance and perspective of objects will appear normal only when they are seen from the accustomed direction. If a staircase is looked at from above instead of from below (and still more if it is photographed from above instead of from below), the perspective will appear distorted and confused. The same effect is produced if a steeple is looked at from above instead of from below. Thus appearance and localization are related from the point of view of the experiencing individual. Other instances occur in the spatial perceptions of ordinary life, especially in the estimation of long distances, always a difficult procedure because so many of the ordinary cues to distance perception have ceased to operate. Thus such perception may be very inaccurate with unfamiliar objects, of unknown size, or in an atmosphere of unusual or unfamiliar clarity. The factors of experience and familiarity undoubtedly exist and improve *accuracy* of judgements of distance, although it may be, as claimed by the Gestalt psychologists, that we have an *innate tendency* to perceive space three-dimensionally.

As regards this innate tendency, the behaviour of cases of congenital cataract who have been operated upon and recovered their sight has been studied with a view to determining their ability for spatial localization. Dennis (1934) has collected the evidence, which unfortunately is not very clear, since few cases among those described were systematically tested. It is true that for a period of time after the operation their vision is considerably affected by nystagmoid eye movements. But the general conclusion seems to be that visual spatial localization is poor and inaccurate for a period of time after recovery of sight. Indeed, some patients carry out skilled operations involving localization more easily and accurately with their eyes shut, using touch alone. Thus it seems that the elaborate co-ordination of sensory impressions necessary for accurate spatial localization and judgement of distance requires considerable experience for its establishment.

It has been stressed that judgements of distance *can* be made when all but a very few factors have been suppressed. Such judgements, however, usually involve prolonged inspection, and are often inaccurate and variable. Thus they differ considerably from the rapid and easy perceptions and estimates which normally occur in everyday life, at least with comparatively near objects. It seems fairly clear that the greater the amount of corroborative data, the easier and more direct is the quick and exact apprehension of all the spatial relationships of the surrounding field. But of much more importance than the mere amount of data is their relationship to each other. We have already suggested that the essential factor may be that they can be fitted together into a continuous and coherent configurational structure which comprises the total three-dimensional field, with its variations in form, size, clearness, brightness, colour, and disparity, arranged in continuous perspective. We have noted the manner in which the Gestalt psychologists have demonstrated that the parts of a whole configuration are closely articulated together in an integrated and coherent structure. In the same way, the sensory impressions and cognitive data which we have discussed are in all probability essentially characterized by their relation to the visual spatial configuration. Again, we must remember that our apprehension of space is not dependent only upon the pattern of visual stimulation. A configurational structure such as we have described is essentially bound up with a mass of kinaesthetic and proprioceptive data, in postural schemata of the kind described by Head (1920). As we discussed in the last section, it appears that there is a definite schematic relationship between all these factors, the development of which is a purely spontaneous process, although its form is influenced by the factors of experience which we have mentioned. The ability to create structures of this kind, and to utilize more or less adequately the data which they afford, may be an innate property of the organism. But the completeness and detail of a structure and its modifications by different conditions, objective and subjective, must be determined by actual experience; and so also the particular accuracy and efficiency with which the individual can deal with any particular aspect of the structure and deduce from it any particular relationship of depth or distance.

Disorders of integration affecting the perception and understanding of space have been studied by Russell Brain (1941b) and by McFie, Piercy and Zangwill (1950). Russell Brain found that bilateral lesions of the parieto-occipital cortex might set up agnosia for spatial relationships. Awareness of the absolute and relative positions of objects might be completely destroyed, but not as a result of loss in visual acuity. The patients had difficulty in finding their way about, set out in the wrong direction, ran into objects in their path and could not find their way round them. With unilateral lesions of the parieto-occipital cortex, localization in the left-hand side of the visual field was affected; but the patient could usually compensate for this and find his way about, although he might tend to neglect the left-hand half of the field. He might also find difficulty in dressing himself. But McFie, Piercy and Zangwill (1950) have shown that even when perception of depth and distance can be carried out fairly normally, yet in activities demanding some ideational grasp of spatial relationships, disability may be marked. Thus in copying drawings (even of a simple cube), the parts were not accurately related to one another. In drawing a horse or a bicycle there was fragmentation of detail; the parts were detached from one another and wrongly arranged. The patient could print a whole letter of the alphabet, but could not complete a part presented to him. He would be unable to say how many cubes there were in a cubical block of, say, nine cubes; and would make gross errors in assembling the parts of the 'Manikin' test. He might be unable to draw a simple plan of the hospital ward, or of his own house, although he was perfectly familiar with these and could move about in them without difficulty.

All these observations point to a disorganization of the ideational spatial frame of reference which in a normal adult is more or less closely related to the perceived spatial framework.

Further evidence as to the nature and development of spatial schemes, and especially as to the ideational judgements about spatial relationships which are normally incorporated in them, is given by the extensive investigations of Piaget (1937) and Piaget and Inhelder (1948). In particular, they have discussed the establishment of a practical, sensori-motor use of the spatial arrangement of objects; and the much later formation of the 'representation' of spatial arrangements, and of general and abstract ideas about space. It seems that in early infancy there is not only no general idea, but no perception, of a single spatial continuum. Piaget (1937) found that a child of three to four months reacted to a variety of sensory stimuli, and could be said to be orientated successively towards a 'mouth space', a 'visual space', an 'auditory space', a 'tactile space', and so on. His activities were directed towards the appropriate space, without regard to the others. Thus he did not seize the bottle with his hands, because it belonged to the 'mouth space', but only with his lips. Objects had to him no permanent existence, and there was no co-ordination of these appearances in different sensory modes. The use of visual space was however developed, before it became co-ordinated with other 'spaces', by following moving objects with his eyes, looking for objects which changed position, and adjusting the convergence of the eyes to focus objects which changed their distance, or when he himself was moved. (Convergence was by then reasonably efficient, though not completely accurate till about eight months.) It is doubtful if he distinguished these various experiences from one another; he was merely conscious of following or finding something which had changed. At five to six months,[1] he began to co-ordinate together the visual and tactile aspects of objects, and to reach fairly accurately for objects which he saw close to him, and thus to show evidence of some power of spatial localization. It appeared that space was then differentiated according to his own activities into 'near space' which was 'touchable' and 'distant space' which was not; and within the former, positions gradually became spatially ordered and understood, though not the movement sequences of moving objects.

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[1] The actual ages vary in different children, as Piaget himself points out; but the succession of stages remains much the same, although regressions to earlier stages do occur. Experiments by Cruikshank (1941), and a summary by her of other work, indicate that there are gross errors in reaching before five to six months, but that after that there is some recognition of distance. For instance, the child ceases to reach for objects beyond his grasp.

At eight to nine months he began to realize the changes of size and shape which occur with change of position and distance (as for instance when he brought his face nearer to an object); and to differentiate these changes from change in state or nature of the objects. He began also to find objects concealed by a screen,[1] and to judge relative distances by means of parallactic movement. But he did not until a year or upwards conceive even in a practical way of external space as such, containing objects independent of himself and moving relative to one another and also to himself. The relationship of an object 'placed on' something else was particularly hard to understand, since the lower object seemed to remain a part of the 'ground' and therefore to be unimportant and impossible to manipulate. When he did begin to judge fairly accurately the position of near objects in relation to one another, he still could not image or predict the course of their movements, or of his own movements in relation to them. Not until about one-and-a-half years of age did he become able to make a detour if his path was blocked, or to manipulate objects to cause them to pass through narrow spaces (such as pulling a long stick between the bars of a play pen). Thus the correct practical use of space preceded his ability to plan movement or predict changes of position in space.

The gradual development of spatial perception in the child is corroborated by the observations of Gesell *et al.* (1949). The sensitiveness of the infant of thirty-two weeks to strange surroundings was accompanied by a growing interest in the positions of objects and the relationship of identity to spatial localization, which for a time was greater even than his interest in movement. Moreover, he showed his awareness of objects beyond his reach by stretching out to them. Though he had little idea, before one year of age, of depth and solidity, yet at thirty-six weeks he began to show some recognition of the relationship of two objects in space—that is, their position relative to one another; and this recognition developed through the use of manipulative toys. Towards the end of the first year he began to investigate spatial relations by crawling towards the things he saw. At about fifteen months he became interested in what happened to moving objects, and seemed to relate position to change of position through movement. Towards the end of the second year, as language developed, he began to use space words. 'Where?' was a frequent question, even with regard to more distant places which he could not see but could only visualize. At two to two-and-a-half years he experimented with the paired opposites of spatial position—up and down, in and out, to and fro, far and near, and so on. But he was still readily confused over orientation and direction of movement. He might even lose his awareness of objects if he lost contact with them. The final schematic integration of visual and tactile perception had not been achieved.

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[1] For a time, though, he tended to think of an object as linked to a particular spatial position, and not as possessing the property of motion independent of its identity. Thus if a moving object disappeared behind a screen, he did not look ahead to the point at which it might be expected to reappear, but back to the point at which it disappeared.

Piaget considered that during the third and fourth years, the topological relations of objects became fairly well understood, that is to say, their shapes were accurately perceived and ordered in space. But the child still had to liberate himself from the egocentric state in which he could see the world only as orientated about himself as centre.[1] To achieve correct ideas of orientation, it was necessary that he should be able to see the environment from the point of view of others also, thus realizing how its appearance varied according to the point from which it was viewed, and co-ordinating and generalizing from these variations to a comprehensive abstract idea. Gesell *et al.* (1949) point out the great interest of the five- and six-year-old in the dimensions of objects, and the distance from him of things in his surroundings. Piaget and Inhelder (1948) carried out experiments in which groups of children were shown a relief model of houses, trees, hills, etc., and asked how it would appear from different points of view; or to choose from a number of photographs representing the model seen from different aspects. Those of about six years chose the one corresponding to their view of the moment; and rather older children chose at random. Only those aged eight or nine years and upwards chose accurately the photograph of the model as it would appear from various other points of view. Again, when they were shown a similar model and asked to reproduce it by arranging houses, etc., in the same way on base of the same or different scales, they could reproduce correctly, at four to six years, the topological relation of some of the houses to each other; that is to say, small numbers of objects were correctly grouped, but the groups were not related to one another. At seven to ten years, the relations of left and right, in front and behind, were correctly reproduced, but not the distances between objects, especially when the scale was different from that of the original. Correct scaling of distance was not achieved till eleven to twelve years.

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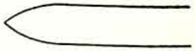
[1] That perception is never completely independent seems to be shown by the fact that size constancy is never quite accurate, that is to say, the perception is to some extent still 'centralized' on the self.

A complete understanding of far distance, and the relation of apparent size to distance, was not attained till a comparatively late age. Again, children were often uncertain as to whether distant objects, such as mountains, which showed apparent parallactic movement as they themselves moved, were actually stationary or in movement. The apparent movements of the heavenly bodies were also understood with difficulty, as witness Piaget's well-known story of the child who thought that the moon was going for a walk with him.

The judgement of distance on the basis of the relationship of retinal size to known real size was not established for distant objects until about seven years. Again, at six to seven years, parallel lines receding into the distance were drawn thus:  At seven to seven-and-a-half years, perspective drawings showed some change of size with distance, but not one that was quantitatively correct.

The co-ordinates of the spatial field were not clearly realized till about nine years. Thus, if children of five to six years were asked to draw people, trees, houses, etc., on the side of a hill, they were likely to choose the perpendicular rather than the vertical co-ordinate in orientating their figures (see Fig. 20 *a*). The transition to the correct use of the vertical came gradually, as shown in Fig. 20 *b*. The correct relation of the main visual co-ordinates to the gravitational co-ordinates was finally achieved at the same period as that at which the child learned to integrate the aspects of a scene from different points of view, when there was a final establishment of the understanding of the Euclidean representation of space.

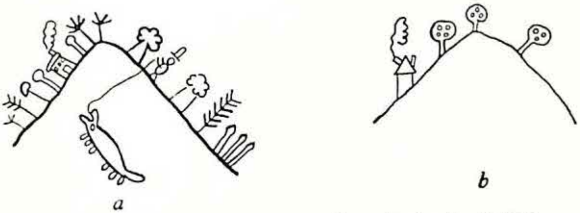


Fig. 20. The development of vertical orientation.

As illustrating the difference between the perception of space and ideas as to the nature of space, it is interesting here to consider the thesis advanced by Luneburg (1947) that even in adults perceived space may be non-Euclidean in its dimensions. The perceived distances of points are not exactly proportional in every case to their geometrical distances as given by the intersection of lines subtended at the eyes by each point. Thus the sun and moon appear of finite size and at finite distances; so also does the sky. But although the perceived dimensions of space are not the same as its geometric dimensions, nevertheless, it may be possible to establish a 'psychometric co-ordination' such that the apparent distance of any two sensed points is always proportional to the geometric distance of the correlated points. Now the scale of size seems to contract with expanding spatial distance, and this contraction appears to have a definite physiological basis in the retina, or during nervous transmission to the cortex, or in the cortex itself. Visual space is thus non-Euclidean in its dimensions. Luneburg has postulated that the metric may be determined by a spatial-differential element of a form which implies the hyperbolic geometry of Lobachevski. The constants in the differential differ for different observers—and even in the same observer at different times. In some individuals, visual and physical space are very nearly alike; in others, they are far apart. This whole postulate of 'psychometric co-ordination' appears a doubtful one, based as it is upon the assumption of the possibility of measuring 'sensations', as apart from sensory stimuli. Nevertheless, it indicates the possibility that individuals do derive their perceptions of distant space in a variety of ways, and by no means in accordance with the exact sensory data on the one hand, or with formulated abstract principles on the other. No touchstone of practical experience is in general available for testing their conclusions, and there is little possibility of checking these against the judgements of others. They are therefore left with a vague impression of immensity, lacking in fixed dimensions, which forms a background to that part of space within their reach, which can be accurately assessed, and which constitutes the basis of the operative spatial framework.

CHAPTER VI

THE CONSTANCIES

(I) INTRODUCTION

We discussed in Chapter IV the tendency of configurations to retain their formal qualities constant as a whole, even when there were changes in the particular elements composing them. We shall now turn to an important and interesting group of phenomena arising from the tendency to perceive as constant and unchanging certain particular sensory qualities of real objects; these phenomena have in fact been termed the 'constancies' by the Gestalt psychologists. The phenomena demonstrate quite clearly the tendency, described in Chapter II, to ascribe an unchanging identity to real objects in the world around us; and, assuming that identity, to perceive little or no change in any of their aspects, even when the retinal images to which they give rise vary greatly in shape, size, brightness, and colour. Such changes of the retinal image occur when the object is tilted from the frontal parallel position (at right angles to the line of sight, when its distance from the observer is varied; and when the light falling on it varies in intensity or hue. But as we shall see such changes are, in the ordinary course of events, attributed in whole or in part to changes of position or illumination of the object with respect to its spatial setting; and not to intrinsic changes in the object itself. Koffka (1935) has endeavoured to relate these phenomena together under one universal physical law. But it will be shown that there are considerable differences between the various phenomena in the extent to which 'constancy' obtains; and that the manner in which it appears varies both with circumstances and also with the attitudes of the observers. This has been made particularly clear in the recent very extensive studies of the phenomena. Consequently comparatively little space will be devoted to the Gestalt laws which were dealt with at some length in the author's *Visual*

Perception (1937b); and more consideration will be given to the variation of the constancy phenomena as studied by different experimenters.

(2) SHAPE CONSTANCY

It is found in general that if a solid object or a flat surface is tilted so that it is no longer at right angles to the line of sight, it tends to appear more or less the same shape as it appeared when at right angles to the line of sight, although its retinal image is considerably altered. For example, a tilted square is seen as square or nearly square, although its retinal image is diamond-shaped. Extensive work on this phenomenon was carried on by Thouless (1931a and b, 1932), who established its existence independently of the Gestalt psychologists, and called it 'phenomenal regression to the real object'—the 'real object' in this case being the object seen in the frontal-parallel position. In his original experiment (1931a) he used a circular shape placed obliquely to the observer's line of sight, so that its retinal image—the 'stimulus character'—was elliptical. The observer was then required to match it against one of a series of ellipses placed at right angles to the line of sight; and he in general chose an ellipse which was less elliptical and more circular than the retinal image. Thus the apparent shape approached the known 'real' shape, but did not quite equal it; there was some degree of compromise between 'stimulus character' and 'real' shape. In fact, when an *index* of phenomenal regression was calculated from the formula:

$$(\log P - \log S)/(\log R - \log S),$$

P being the numerical measure of the phenomenal character, R of the 'real' character, and S of the stimulus character, it was found to lie in the region of 0·6 to 0·8—whereas it would have been 1·0 had constancy been complete, and 0 had it been zero.

This phenomenon could not be explained simply as an example of the Law of Prägnanz, namely, that we have a natural tendency towards certain favoured simple forms, and that objects seen in perspective tend to appear as circles, etc., because these are the forms with which we are most familiar. For Thouless found that phenomenal regression also occurred when an elliptical shape was shown in such a manner that its retinal image, seen in perspective, was circular; in this case the apparent shape was elliptical. But Thouless also showed that in certain cases the index of phenomenal regression could be reduced until it approached zero, the apparent shape coinciding with the stimulus character. If all perceptual cues which indicated the 'real' character of the object were eliminated, by viewing the shapes monocularly against a black velvet background, regression was completely eliminated, and the phenomenal shape of the object was the same as that of its retinal image. An ingenious variant of this experiment is suggested by Ames (1946b): if a window is rotated in its frame until it is almost end-on to the observer, it will still appear as a rectilinear window. But if the image of the rotating window cast on a photographic plate is viewed, then its shape will appear to change continuously, that is to say, it will approximate to the retinal shape—the other perceptual cues having been eliminated.

Again, if some of the perceptual cues were retained, the amount of phenomenal regression was proportional to the amount of perceptual cue. Thus partial closing of the eyes to throw the object out of focus, or the steady fixation of one point, had such an effect. A diminution in the clearness of the outline reduces the organization of the field and the segregation of the perceived object from its background; and hence also the effect produced by the 'real' character of the object. But knowledge that phenomenal regression is occurring does not in any way diminish its effect. Practice in perspective drawing may decrease it somewhat, but does not destroy it. Eissler (1933) found further that the absolute amount of transformation or regression from the retinal shape increased with increase in the angle of inclination; but that the degree of constancy, that is, the relation of apparent to 'real' shape decreased with increase in the angle of inclination. That is to say, the observer made increasingly greater attempts to allow for the increased tilt, but these attempts did not completely compensate for the increase. Eissler considered that the constancy depended on the observer's perception of the orientation of the shape to its background. According to Koffka

(1935), this relationship, like that of the 'spatial framework' (see p. 84) would be 'invariant', while the 'neutral level' towards which the shape tended would be that seen when the shape is in the frontal parallel position. But Sheehan (1938) and Stavrianos (1945) found that the relationship between constancy and angle of tilt was an irregular one. We shall deal more fully with this phenomenon in section (5) of this Chapter.

(3) SIZE CONSTANCY

Size constancy and shape constancy are related, but are also to some extent independent of each other; size constancy in general being greater in amount than is shape constancy. That is to say, if an object is made to recede from the observer, or is presented to him at some considerable distance away, it will appear to be of the same size as if it were seen at a short distance only. This phenomenon again varies in extent for different observers. But most experimenters, other than Thouless (1931a, 1932), have found that the index of phenomenal regression approximates to 1·0 for the majority of adults up to a considerable distance. That Thouless obtained lower indices, of the order of 0·6 to 0·7, was due to the fact that in his experiments the distance of the variable object was varied while its size was kept constant at an amount less than that of the standard object. Thus it was impossible for the observers to show complete constancy, with an index of phenomenal regression of 1·0. His instructions also stressed the adoption of an 'analytical attitude', the effect of which we shall discuss in Section (5) of this Chapter.

However, it appears that in general, in normal everyday experience, the decrease in size of the retinal image of a receding object appears as an increase of distance and not as a decrease of its size. Clearly then, for the phenomenon to appear, the observer must have some knowledge of the size of the object when it is close to him, or else some means of judging its distance. If both sources of information are suppressed, for instance, if the observer views an object of unknown size against a dark background, with all view of the surroundings concealed, and hence all cues as to distance eliminated, then the index of phenomenal regression may approach zero. The greater the amount of information available as to the exact size or distance of the object, the greater the degree of constancy. Beyrl (1926), for instance, found that constancy was greater with solid three-dimensional objects, which can be readily fixated and localized, than with flat ones. Sheehan (1938) found it greater for both a triangle and a cube than for a circle. Weber and Bicknall (1935) found it to be greater in stereoscopic vision of the photographs of distant objects than in non-stereoscopic vision. Lambercier (1946 a and b) and Piaget and Lambercier (1946) measured the degree of constancy when the observer had to equate one of a series of strips of wood of variable height, at four metres distance, to a standard strip at one metre. The constancy of adult observers was increased when four strips, known to be equal in height to the standard, were placed between the standard and the variable, and slightly to one side of the line between them. Constancy increased to a less extent when the subsidiary strips of wood differed in height from the standard. But it was even increased to some extent when only a single strip, equal in height to the standard, was placed between standard and variable, to one side of the line between them. It appeared that the observers used these subsidiary strips as intermediaries in the comparison between standard and variable. But children, especially younger children, showed a different reaction to the setting, and this will be discussed in Section (5).

Rather similar experiments were carried out by Gibson and Glaser (1947), using a natural, not a laboratory, setting. A number of strips of wood of variable length were placed fourteen feet from the observer in a row at right angles to his line of sight. The standard, of unknown height, to which one of the variables was to be equated, was placed at much greater distances, up to a quarter of a mile away. Constancy was found to be very high; indeed, there was a tendency to 'over-constancy',[1] that is to say, to over-estimate the height of the standard. Constancy was also very high when judgements were made from photographs of this scene, instead of from the natural setting itself (although the variability of results was greater). Here then the observers could perceive the general setting with sufficient clarity to make accurate judgements of distance; and thus to perceive the distant object as being of the same size as it would appear when quite close. Brunswik (1944) obtained similar results with objects seen in their natural surroundings. His observer was asked to estimate in metres the heights of various natural objects at different distances. The index of phenomenal regression averaged 0·9, although it was slightly less for more distant objects, when the estimates of distance were also more variable and less accurate.

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[1] A full discussion of 'over-constancy' is given on p. 143.

Size and shape constancy are also high in the viewing of cinema films. Even to an observer sitting at the back of the cinema, the objects on the screen appear to be more or less of the same dimensions as they would appear in ordinary life. Yet if he closes one eye and holds up a match box, he will find that it will cover the whole screen even when held almost at arm's length. The constancy phenomenon is, however, dependent on the fact that the general illumination of the cinema is normally sufficient to allow the observer to locate the screen spatially. In the early days of cinematography, as Thouless has noted, the cinema was often kept completely dark, on account of the feeble illumination of the screen. It was then difficult for the observer to localize the screen; size constancy was impaired, and the screen and the objects on it tended to appear absurdly small. Again, as Oldfield (1948) points out, the very small photographic images produced by projecting 9·5 mm. film have a slightly unreal effect. In ordinary life, images of such a size would be produced on the retina by objects at a very great distance away; thus when they are viewed in a room, size constancy cannot operate to make them appear like the retinal images of everyday life.

The phenomenon of shape constancy can also be observed in the cinema. If the screen is viewed from one side of the cinema hall, objects on it will appear to some extent distorted, but much less so than are their actual retinal images.

Some recent experiments by Joynson (1949) suggest that the degree of constancy depends in part upon whether the observer is estimating the size of an object from the immediate impression of its size as a 'real' object, or from the proportion of the visual field which it occupies. Thus, as was pointed out by Stout (1938, p. 679), if a house seen through a window is regarded simply as a house, it will appear full-sized and constancy will be more or less complete. But if it is regarded as filling a comparatively small proportion of the window aperture, it will then be judged from the size of its retinal image, and constancy will be slight. Thus the degree of constancy will vary with the attitude or purpose of the observer in perceiving. Joynson showed that when the observer was asked to match the 'real' sizes of the test and variable objects, constancy was almost complete. But if he was asked to match the two objects according to the relative amounts of the background they appeared to cover, then the index of phenomenal regression was considerably lower; but it could be increased by increasing the angular separation of the two objects. Joynson considered that in the first situation the observers were employing a synthetic attitude; in the second, an analytic attitude. We shall return to this question of the effect of attitude in Section (5).

Some curious observations have been made with regard to the relationship of the degree of size constancy to the angle at which the object is viewed. This fact is demonstrated in the familiar phenomenon of the 'horizontal moon'; the moon on the horizon appears much larger than the moon at the zenith. Schur (1926), working with illuminated circular patches of light, found that the degree of constancy of objects situated vertically above the observer decreased at thirty-three metres till it was only about 50 per cent of the constancy of objects situated straight in front of him. This phenomenon was apparently related to the position of the observer; if he lay flat on his back and compared the size of an object overhead with that of an object horizontally behind him, the latter appeared relatively smaller than the former. These observations were confirmed by Holway and Boring (1940), who found that the phenomenon depended on the elevation of the eyes in the head, and not on the position of the body as a whole. There seems then to be a tendency to under-estimate the size of objects seen above the head, possibly as the result of a tendency to under-estimate distances in the upward direction. The phenomenon may also be connected with the non-Euclidean dimensions of perceived space noted by Luneburg (1947) (see p. 117). No frame of reference is developed above the head, and thus accurate estimation of distance in this direction has never been developed. Taylor and Boring (1942) have pointed out that the comparison object used for measuring constancy also loses its frame of reference in that direction, and appears to vary in size according to the size of the retinal image.

(4) COLOUR AND BRIGHTNESS CONSTANCY

These phenomena were first described by Helmholtz (1896), and have since then been the subject of innumerable discussions and experiments. They may be described roughly by saying that if the general illumination of a field containing objects is changed, either in colour or intensity, the apparent hue and brightness of the objects illuminated does not change in the same way or to the same extent as does the light actually reflected from them to the retina. In general, their colour and brightness tend to approximate to their colour and brightness in 'normal illumination' (which, as we shall see below, is the illumination given by achromatic daylight of moderate intensity). Thus if the achromatic illumination of a white surface is gradually decreased, the surface continues to appear white even when the total amount of white light reflected is very small; and if the illumination of a black surface is gradually increased, the surface continues to appear black, though actually it may reflect more light than the white surface in dim illumination. Again, a white surface in a red light may up to a point appear less red than a red surface in white illumination, even when the former reflects more red light than the latter.

It is clear that the observer must in some way be able to differentiate in the perceived colour and brightness that part of it which is contributed by the general illumination and that part which is contributed by the intrinsic colour and luminosity of the objects illuminated. He is able to tell if illumination changes and not object colour or if object colour changes and not illumination; and, in the former case, he may greatly underrate the nature and extent of the change, hence achieving an impression of approximate constancy in the hue and brightness of the objects illuminated.

It has been postulated by Katz (1935) that the differentiation is related to the phenomenal variations in the nature and appearance of the colours[1] of objects. In general, when the latter are clearly perceived as a 'figural' experience, they possess 'surface colour'; that is to say, the colour seems to exist actually in the surface of the object perceived. The colour is thus localized in the same position as the surface, and moves with it; moreover, it is hard and resistant to penetration, as is the surface. It usually possesses a minute structure and patterning called the 'micro-structure', which is characteristic of the physical constitution of the surface. The illumination in which this micro-structure is most clearly visible, generally achromatic daylight of moderate intensity, is called the 'normal illumination', and the surface colour is then held to constitute the 'genuine colour' of the object—that is to say, its characteristic colour by which it is remembered and recognized, and to which its colouration in other illuminations is unconsciously referred. If, however, perception is modified in certain ways—whenever the configurational structure of the field is lacking or obscured, and the micro-structure no longer visible—the colour appears as a film; it is soft, spongy, unresistant, is no longer superficial but has considerable depth, and its plane is always parallel to the frontal plane of the observer. Moreover, it does not always appear as a characteristic of a definite object of known spatial structure, but of an indefinitely extended substance such as the sky. The replacement of surface by film colour occurs if clear vision is prevented, for instance, by lack of accuracy in accommodation. Thus if the object is observed through a small hole in a screen placed at an appreciable distance from the observer, the eyes are accommodated on the screen, not on the object; and the colour of the latter is said to be 'reduced' to the mode of appearance of film colour, at the same general illumination as that of the screen.

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[1] Throughout his book, *The World of Colour* (1935), Katz seems to apply the word 'colour' both to neutral, achromatic colours and to the chromatic colours, except when specially qualified.

In the same way, other modes of appearance of colour—the 'volume colour of fluids, 'transparent colours', lustre, etc.—can also be 'reduced'. By suitably controlling the colour and brightness of the aperture screen (called a 'reduction screen'), the hue and intensity of retinal excitation can be kept constant under reduction, showing that the changes of mode of appearance are not due to variations in the retinal process.

It then appears from these observations that an impression of the general illumination is dependent upon the apprehension of the objects in the field as objects—and in general, though not universally upon the perception of the surface colour of these objects. Gelb (1930) has demonstrated the existence of colour constancy of a kind in certain pathological cases who could perceive object colours but not surface colours. But, in general, if a part of the field be viewed through a reduction screen, colour constancy is destroyed, and its colour approximates to that of the light actually reflected to the retina. Thus suppose that two surfaces of different albedos—a light and a dark grey—be exposed, the first in a dim illumination and the second in a brighter illumination; by suitable variation of the illumination the two surfaces can be made to appear equally bright when viewed through a reduction screen. This can be done by altering the relative distances of the surfaces from the light source; or by viewing them through episcotisters with open sectors of varying angles. When the screen is removed, the light grey will appear lighter in colour quality than the dark grey. In suitable circumstances (for instance, with fairly long exposures of the comparison surfaces), and particularly with certain individuals, almost complete colour constancy may be demonstrated. That is to say, varying the brightness of the illumination will not affect the apparent colour relations of the two surfaces in any way, except when they are viewed through the reduction screen.

Certain observations seem to show that familiarity affects the phenomenon, and that constancy in unfamiliar chromatic illuminations is less than in achromatic illumination; but a certain degree of constancy does occur, until the illumination becomes almost completely monochromatic, when it breaks down entirely. Helson

(1938), however, found that achromatic surfaces might retain their achromatic appearance until as much as 93 per cent of the incident light was chromatic. And in a later experiment, he found that chromatic surfaces showed an even higher degree of constancy. It is not clear, however, whether the observers were aware of the 'real' colour of these surfaces—that is, their colour in achromatic light. Such an awareness may have considerable effect on the degree of constancy.

According to the theory of Helmholtz (1896), the phenomenon of colour constancy is due to the observer's awareness of the 'real' colour or 'memory colour' of objects. The observer is able to estimate the colour and intensity of the general illumination; and then to discount the effect these produce on the colours of objects in the field, hence arriving at an impression of their 'real' colour. The immediate sensational effect is thus counteracted by an 'unconscious influence of judgement' based upon the results of practice and experience in associating certain characteristic colours with certain familiar objects. This theory in its original form has been discarded, but there seems to be some experimental evidence for the influence of 'memory colour'—that is, the colours habitually associated with objects. Though laboratory experiment usually stresses the sensory aspect of colour, the ordinary experiences of everyday life accentuate the cognitive and even affective aspects of colour experiences. A most interesting piece of work which was carried out by Adams (1923), but never unfortunately followed up except by a single brief experiment of Duncker (1939), suggested links between the cognitive and the sensory aspects of colour. In the first place, Adams collected a large number of instances recalled by various people of cases of visual illusions occurring in everyday life in which it appeared that the perceived colour, brightness, or texture of objects were a function of the apparent identity of the objects. That is to say, when a particular perceptual experience suggested first that a certain object was being seen (often as a result of the expectation of seeing that object), and was then realized to be illusory, and was identified as some other object, then the apparent hue changed from that appropriate to the first object to that appropriate to the second. Adams quoted about a hundred such instances; some of these related to auditory, tactile, olfactory, and gustatory experiences, but the majority to visual experiences. Here is one:

> I was looking out of the window, watching for the street car, and I saw through the shrubs by the fence the brilliant red slats of the familiar truck; just patches of red, brilliant scarlet. As I looked, it occurred to me that what I was really seeing were dead leaves on a tree; instantly the scarlet changed to a dull chocolate brown. I could actually 'see' the change, as one sees changes in a theatre with a shift of lighting. The scarlet seemed positively to fall off the leaves, and to leave behind it the dead brown. I tried to recover the red by imagining the truck, and found that I could redden the leaves somewhat; then I made them leaves again, and found that I could brown them somewhat; but I could not get either the original scarlet or the later dead chocolate. I went out to see what the colour 'really' was, and found it to be a distinctly reddish brown. . . (Adams, 1923, p. 359).

Similar instances are probably familiar to everyone, of the changing appearance of shadows seen as parts of objects rather than as shadows. These phenomena were related to the 'memory colour' of Hering (1905), and to the 'surface colour' of Katz. Adams, in the second part of her investigation, endeavoured to get observers to match various natural colours, such as those of grass, snow, etc., and various coloured objects, with colours presented artificially in the laboratory. She found that the perception of the natural colours was subject to an 'imaginal overlay' produced by the 'memory colour' of the real object, transforming the perceived colour from that of the retinal image to that of the remembered 'real' object. If, however, a critical attitude was adopted during matching, then the memory colour was more or less completely eliminated, and matching was based largely on the colour of the retinal image. But extreme familiarity with the remembered object enhanced the effect of the memory colour. Similar experiences could be obtained in other sensory modes.

In Duncker's experiment (1939), a shape resembling the silhouette of a leaf and a shape resembling the silhouette of a donkey were cut from green paper and presented to the observers in an almost monochromatic red light. The observers had then to match the colours of these shapes with that of a colour wheel which had variable green, orange, black, and white sectors. A majority of the observers made a greener match to the 'leaf' than to the 'donkey'. The inference was that the green 'memory colour' of the 'leaf' caused it to appear greener than the brown 'memory colour' of the 'donkey'. But the difference of the two matches was in no case great, and with some observers was non-existent. It did not appear that more than a small part of normal colour constancy could be attributed to 'memory colour'.[1]

Thus although constancy may be to some extent a function of 'memory colour', some further explanation is required to account for the system of related changes in the colour and brightness of objects and their surroundings, and the effect upon these of the structure of the field. Such a theory has been advanced by Katz (1935). It seeks first to explain how it is that we are able to perceive changes in the intensity of the general illumination apart from changes in the colours of objects. Katz points out the enormous difference in the scale of perceptible intensity change in illumination and the scale of perceptible brightness change of the colours of objects. Thus the greatest intensity of illumination in which objects are visible is many thousand times the least intensity; but the ratio of brightness of the most dead black surface to the brightest white is only 1 : 60. There will then be a strong presumption that any general or widespread changes in the apparent brightness of objects will be due to changes in the intensity of illumination, which occur relatively freely; whereas objects in preserving their constant identity will be assumed to retain their intrinsic brightness unchanged.

Again, when the illumination changes hue as well as intensity, the illumination, according to Katz (1935), is judged to be chromatic when (1) all the objects in the field are uniformly tinted by it; (2) all colour irregularities in the micro-structure of surface colour become fused. When these effects are perceived, the general illumination may be apprehended as chromatic, even when the actual colour involved is quite unfamiliar. But it is not always thus apprehended when it is faint and its effects slight. The colour quality of objects in the field will appear to remain relatively constant, and to approximate to their 'genuine colour'—the surface colour as it is seen in normal illumination, which approximates to 'memory colour'. If a surface is moved nearer to or further away from a source of illumination, then again the change is perceived as a change in the local specific illumination of that part relative to the general illumination, together with constancy of colour quality. Thus within the totality of the visual field there are sub-totalities following their own laws. The clearness with which a sub-totality appears as such varies with its size relative to that of the whole field. But in all cases it is necessary for the observer to perceive and recognize objects as such to observe their configurational relationships and if possible their micro-structure.

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[1] A recently reported experiment by Bruner, Postman and Rodrigues (see Blake and Ramsey, 1951, p. 133) showed that 'memory colour' was operative only when the stimulus conditions were ambiguous. Observers were required to match with a colour wheel pieces of paper cut in the shapes of a tomato, orange, banana, etc. The match was not significantly more red for the normally red objects, and less red for the normally yellow objects, when the shapes were cut from orange paper. But there was a significant difference when grey paper was used, placed under ground glass on a blue-green background—that is to say, when the stimulus colour was highly unstable.

It is clear that these processes of differentiation must be based upon some well-established scheme of relationships between the known colours of objects, their 'memory colours', and the specific changes they undergo in various illuminations. It is not necessary to suppose that the observer, to establish such schemes, must have consciously experienced all the varying related degrees of illumination colour and object colour. But Katz considers that regular organizations of meaningful serial combinations are formed in accordance with the principle which he calls 'chain-association'. This can be distinguished from ordinary association in that the latter can take place between totally independent and irrelevant items, provided that they are presented either simultaneously or in immediate succession to consciousness. It is clear, however, that in colour schemes, all the items are related in continuous scales or series (often continuously experienced, as in gradually waxing and waning daylight); each degree of each series is essentially relevant to all the other degrees of that series and of the other series constituting the scheme. Hence once a few isolated items have been experienced, all the related series can be induced, and any other required items deduced—and this apparently at the perceptual level, without any intervention of conscious judgement. This colour scheme is thus similar in many respects to the schematic relationship which it was suggested in the last chapter existed between the various factors contributing to the perception of depth and distance.

The theory of Koffka with respect to colour and brightness constancy is similar to that of Katz. But it attempts to go further, and to describe the scheme of relationship between object colours, the colour and brightness of the surroundings, and the structure of the field. Like Thouless (1932), Koffka (1935) distinguishes between 'whiteness', on the white-black achromatic colour scale, and brightness, which results entirely from intensity of illumination. If two surfaces have the same 'reduction value', as in the experiment described on p. 128, the surface of greater whiteness will, in the absence of the reduction screen, look less bright than the surface of less whiteness. This points to the conclusion that the combination of whiteness and brightness—probably the product—is constant, or, as Koffka terms it, 'invariant' (1932). Thus the greater the whiteness the less the brightness (and vice versa) for a given local stimulation—or reduction value—under a definite set of total conditions. Consequently if the brightness of a surface can be deduced from its relation to its structural setting—the brightness of the surroundings—the whiteness is immediately inferred. Moreover, all degrees of whiteness can easily be produced by variations in brightness, since as Katz pointed out (see p. 131), the total possible range of brightness is some sixty times greater than the total possible range of whiteness.

Koffka then cites various experiments which demonstrate the effect upon constancy of the structural relationship of objects and their settings. In an experiment of Hering (1905) a white screen with a hole in it is set in front of a fairly well-illuminated wall. When at first the screen is totally dark, the brightness of the hole is taken to be as low as that of the screen, and its whiteness is therefore inferred to be high; in point of fact it does appear white. When the screen is brightly illuminated, the hole appears black, since now it is inferred to be as bright as the screen and therefore to have a low degree of whiteness.

This effect might of course be explained as being merely an instance of simultaneous contrast; but this explanation will not hold for another experiment by Jaensch and Müller (1920). In this experiment, two discs were exposed immediately in front of backgrounds to left and right of a separating partition, which threw a shadow on to the right-hand background. But the latter was made whiter than the left-hand background, so that the two were 'reduction equal'. When the two discs were then also made 'reduction equal', the left-hand disc still appeared to the observer blacker than the right after the reduction screen had been removed. But no contrast effect could be taking place, since the total amount of light reflected from the two backgrounds was the same. The discs had equal 'gradients' to their respective backgrounds and looked as much unlike one another as did the backgrounds. And presumably the unlikeness of the backgrounds was perceived to be due to the inequality of their illumination.

Certain experiments of Gelb (1930) and Kardos (1934) throw further light on structural relationship between surface and background which determines the nature of the gradient. The latter appears to depend on the 'appurtenance' or 'belongingness' of objects to the 'figure' or the 'ground'. In Gelb's experiment, a homogeneous black disc B, strongly illuminated by a projection lantern, was rotated in a dark room A. Then the disc B appeared white, and the room A black. But when a piece of white paper C was held close to the disc, so that it appeared to 'appertain' to the disc, C appeared white, B became black though as bright as C, and A looked black and dark. Thus the whiteness of B was determined by the gradient between B and C; the constancy effect held between B and C, which were perceived to appertain to one another, and to receive the same illumination. Kardos then found that if the experiment was so arranged that A was perceived to appertain to B, then C appeared white and brighter than B; B appeared white but dark, and

A black. Here the whiteness of B was determined by the gradient between A and B, since they appertained to one another. If, however, the conditions were less simple, and B did not appertain completely either to A or to C, then there was no longer equality of whiteness between B and C (or A) and equality of brightness between B and A (or C), but intermediate values of both. In general, however, these experiments show that two areas in the same plane will determine one another with regard to whiteness; whereas areas organized in different planes will determine each other with regard to brightness. Actually it may be that the white-black scale is not completely symmetrical, and that the white end possesses certain characteristics which are not shown by the black end.

Koffka's theory then seems to be as follows: the characteristic quality of whiteness of a surface (with its attendant qualities of hardness or thickness) is determined by the gradient between its albedo and the albedos of other surfaces situated in the particular plane in which it is organized. Its brightness is determined by its relation to the organization of illumination of its surroundings, and varies with this; while its whiteness, and the whiteness gradients between it and the other surfaces receiving the same illumination, remain constant, or comparatively so. If two surfaces are perceived to be organized under different illumination conditions, they will appear different, that is, possessing different degrees of whiteness, even though the same total amount of light may be reflected from them to the eye. If, however, the spatial organization of the surfaces and surroundings cannot be seen, these phenomena will disappear and the parts of the field will appear to differ merely in brightness.

Wallach (1948) has repeated and extended these experiments, and has propounded rather a different theory to cover their results. He considers that constancy occurs when the observer perceives that the proportion of reflected to incident light remains constant. If an observer is asked to equate the 'whiteness' of two discs surrounded by rings of different brightness, he will make the ratio of one disc to its ring equal to that of the other disc to its ring. The rings constitute the surroundings, other surroundings being in darkness. The comparison becomes more complex when the latter are visible.

As the total field is varied, so it is found that the extent of constancy varies with its structural organization. Thus Cramer (1923) and Granit (1926) showed an increase of constancy with the presence of figures in the field. Katona (1929) found that better organization, with more form, contours, and object character, increased constancy. Henneman (1935) considered that the less homogeneous the ground, particularly if it possessed three-dimensional structure, the greater the constancy. Macleod (1932) found that constancy appeared best when an object was seen standing out in front of a shadowed background, the shadow being clearly seen as such. (This is comparable to the effects of Gelb and Kardos.) But if a shadow was surrounded by a contour line, either black or white, it became a 'figural' phenomenon, with 'thing' quality, and constancy appeared in the form of a much blacker surface colour. This phenomenon persisted whether or not the observers could see that it was a shadow and whether or not they had been told it was a shadow. It was a function of that part of the field organization which underlies the differentiation of 'figure' and 'ground'.

More recent experiments by Macleod (1947) seemed to show that field organization, and the appearance of constancy, depend on the sharpness of the brightness gradient and the firmness of the contour between fields. We have already noted (on p. 43) the relation of the sharpness of contour to the 'figure-ground' experience and (on p. 54) of the position of contour to the apparent brightness of the enclosed areas. In Macleod's experiments, these findings were extended by demonstrating the spontaneous formation of contours by increasing brightness differences, and by relating these to the constancy phenomenon. Behind a neutral grey disc were rotated two colour wheels, one larger than the other. Sometimes the brightness of the larger wheel, producing the outermost ring, was varied; and sometimes the brightness of the other wheel, producing the inner ring immediately surrounding the disc, was varied, while the outermost ring was held constant. In the latter case, when variation was slight so that there was a gradual change of brightness from the disc through the inner to the outer ring, the inner ring did not appear strongly demarcated from the disc, but was seen as a gradient or shadow on its outer edge. A brightening gradient then brightened the disc, and a darkening gradient darkened it; that is to say, the brightness of the disc changed in the direction of constancy. But if the inner ring was made much brighter than the disc or the outer ring, it appeared as a contour sharply demarcated or even in a different plane from the disc; and the disc showed a contrast effect and seemed to be darkened. The conclusion thus seems to be that where slight brightness differences produce the appearance of gradual shading, with no discontinuity of the two fields, then there is brightness constancy. But where sharp brightness differences of the fields produce structural discontinuity and contour effects, brightness contrast will result. A similar effect was demonstrated by Wallach (1948), who considered that constancy depended upon both the disc and the ring being seen to have 'surface colour'.

It seems clear that achromatic colour and brightness constancy are closely related to the manner in which the field is structured. In general, it may be concluded that constancy operates most strongly with those parts of the field which have acquired the maximum degree of 'thing' or 'object' character. But colour contrast may operate in those parts of the field which are seen merely as surfaces in approximately the same plane as one another. It seems probable that the same type of effects operate in chromatic colour constancy, but here the phenomena are more complex and difficult to explain. In the first place, even fairly obvious 'object colours' may show an appreciable modification of hue in chromatic illumination. As Koffka (1935, p. 256) points out, 'ladies . . . will not choose dress material in artificial light'. Yet, as we noted above, Helson (1938) found that some degree of constancy was retained even when a high proportion of the incident light was chromatic.

Koffka (1935) quotes the following experiments: If at dusk the electric light is turned on in a room, the windows of which are covered by white muslin curtains, the latter will immediately appear blue, provided the light outside and inside are of approximately equal intensity. Again, if the shadow of an object is cast upon a white wall by a diffuse mixture of daylight and electric light, the wall will still appear white, but the shadow blue. These are not examples of normal colour contrast; for in the case of contrast, the surroundings would have to appear yellow for the shadow to appear blue. Again, if the shadow is surrounded by a sheet of yellow paper, it will cease to appear blue and will become neutral; whereas if the blueness were due to colour contrast, it would then be enhanced. Koffka attributes these phenomena, and those of colour constancy, to a tendency to see the surroundings or colour frame as neutral, or as neutral as possible. But there is also an 'invariance' in the gradient between the object and its surroundings. Therefore, when the hue of the surroundings is actually changed, there will be a corresponding shift in the apparent hue of the object. This neutralizes the actual change in hue of the reflected light from the object produced by the change in hue of the illumination. The result is colour constancy.

When, however, the general illumination becomes increasingly monochromatic, the neutrality of the 'level' can no longer be maintained; and the shift cannot compensate for the change in the reflected light. Constancy breaks down, and the various parts of the field appear neutral-coloured, differing in brightness and whiteness (or rather, of course, greyness), while the illumination may be perceived as coloured, or at least differently tinted from neutral illumination. Again, as has been shown by Helson and Judd (1932), to an observer wearing weakly coloured spectacles, complete colour adaptation occurs, and objects resume their normal colours. But with strongly selective, monochromatic spectacles, the dominant colour persists for many hours, though it may undergo a slight shift towards the neutral 'level' (that is, some loss of saturation) during the first few minutes.

In contradistinction to the above theories which stress the perceptual and configurational aspects of the phenomenon are those which attempt to explain it as a retinal phenomenon. Hering (1905) considered that constancy was maintained through the operation of retinal adaptation and of the pupillary functions. But Katz (1935) was able to show that constancy could be destroyed when retinal excitations remained unchanged. Bühler's theory (1922), that we estimate the colour and intensity of the general illumination from its reflection from minute particles of dust in the air, has also been shown by Katz to be untenable. For the colour constancy effect does not vary (within wide limits) with the distance of objects, that is to say, with the amount of the intervening air space and dust particles; and it obtains at distances so short that the amount of light which could be reflected from these particles would be subliminal.

Jaensch (1920) attempted to demonstrate that colour constancy is essentially the same type of phenomenon as colour contrast, and that the laws governing the latter may be extended to cover the former if the term 'circumfeld' (surrounding field) in the latter be replaced by the term 'illuminated space' for the former. But the constancy phenomena appear to be far more labile and variable in different individuals, as we shall describe in the next section, than are contrast phenomena. Indeed, when 'figural' conditions are kept constant, the latter appear to depend only on the intensity and wavelength of retinal excitation; they are independent of the structural relations of the field. But lately Wallach and Galloway (1946) have returned to this theory and argued that when a coloured object is illuminated by light of a different hue, the reflected light will have a hue intermediate between that of the object and that of the illumination. Contrast will occur between the hue of the reflected light and that of the illumination, which tends to enhance their difference of hue. Thus the perceived colour will tend to approach that of the object colour. In support of this theory, Wallach and Galloway carried out numerous experiments in which contrasting colours were so arranged as to have exactly the same hue and brightness as those produced by constancy effects. The two effects appeared identical in every respect, whether both appeared as surface colours, both as luminous or 'film' colours, or one as surface, the other as luminous colour. Such a theory does not, however, appear to explain the curious effects associated with 'memory colour' described above—or, indeed, the greater constancy of colour definitely associated with an object.

Helson has also put forward the results of some interesting experiments (1938) as supporting the view that a common mechanism accounts for all the phenomena of contrast, constancy, and transformation. He found that in monochromatic illumination the hue of the surfaces perceived depended largely on their reflecting power. Thus surfaces which reflected a high degree of the incident illumination (that is, bright surfaces of similar hue) appeared to be of the same colour as that of the illumination. Surfaces which reflected little of the incident light (either because they were dark or else because they were of unlike hue) appeared of a complementary colour to that of the illumination. Other surfaces of medium reflecting power appeared achromatic or highly desaturated. However, Helson found also that the admixture of a very small amount of white light (of intensity of 0·3 foot candles) to the monochromatic illumination (of intensity 72 foot candles) began to restore constancy, and that the latter became complete with the addition of white light of 4·5 foot candles. Thus the above results, although they demonstrate what occurs when the conditions for constancy are destroyed, do not seem to indicate what relationship obtains between these effects and the constancy that occurs when illumination is not monochromatic.

The present discussion does not appear to lead us to any final conclusion. But an explanation in purely retinal terms of the constancy phenomena appears unlikely to be true, and it seems more probable that both the 'memory colours' of objects, and also the perceived structural relationships in the field must be taken into account.

(5) INDIVIDUAL VARIATIONS IN THE PERCEPTION OF CONSTANCY

It must be noted in the first place that much work has been carried out to determine whether constancy operates more or less strongly in the more primitive perceptual processes of animals and children than in the more highly developed and critical perception of adult humans. As in the case of other Gestalt phenomena, it has been the concern of the Gestalt school to demonstrate that constancy in animals and children is as great as, or even greater than, that in adults. Thus Katz and Révész (1921) found that colour constancy existed in hens; Burkamp (1923) found that it was high in fish; and Locke

(1938) found the same for monkeys. Burzlaff (1931) found that in matching a standard grey against a series of variables, constancy was as great for children as for adults; but in matching against a colour wheel it was considerably lower for children under seven years of age. Brunswik (1929) found an increase of constancy up to ten to eleven years even, in matching squares of grey paper.

With regard to size constancy, Köhler (1915) found that chimpanzees and hens trained to eat from the larger of two boxes, or the larger of two sizes of grain, continued to do so when the larger objects were moved to such a distance that their retinal images were a good deal smaller than those of the smaller objects. Locke (1937) found that size constancy in the perception of two squares viewed at eye-level varied over a range of 0·6 to 0·9 in monkeys, children of four years, and also adult humans. Brunswik and Cruikshank (1937) found that size constancy was slight in infants of four to six months; but that it increased regularly from six to twelve months, by which time it was almost complete. Frank (1926) also found it to be good from eleven months upwards. Burzlaff (1931) considered that size constancy was as great in children as in adults, but Beyrl (1926) maintained that it increased up to the age of ten years. According to the results of Thouless (1932), it appeared to go on increasing even during adult life. But Thouless (1933) and Beveridge (1935) found constancy to be greater in native races (Africans and Indians) than among adult Europeans.

Piaget (1945), on the basis of observations of children's spontaneous behaviour, considered that size constancy for near objects was achieved completely during the first year of life, in the sense that they had no difficulty in recognizing objects at different distances. This recognition was presumably due to the fact that the child had perceived familiar objects being moved from one position to another and had assumed that they retained their identity with change of retinal size. Moreover, he had himself been able to check this impression by moving objects to and fro, or by moving his body towards or away from them. On the other hand, it seemed to Piaget from children's remarks and answers to questions that they did not achieve constancy for more distant objects till after five years of age.

Moreover, it appeared that they did not understand and accept the identity and continuing existence of distant objects till that age. Thus one child did not realize the identity of a village seen at a distance with the same village seen when close. It is obvious that for really far-distant objects, such as villages seen from a mountain side or across a lake, complete size constancy cannot be *perceived*; the houses really look tiny. But we can *judge* that the village is identical with the same village seen when close on the basis of our experiences of the changes in perceived size (not merely retinal size) with great increases of distance; so that we come to *know* that those toy-like objects are really houses, though they do not look like real houses. Very naturally the child may not have had the experience necessary to establish this knowledge, and cannot therefore make this judgement. On the other hand, there may be some effort towards 'phenomenal compromise', or compensation of perceived size with respect to perceived distance. Thus distant mountains usually appear considerably higher when seen directly than in a photograph. It would be interesting to investigate in more detail how much compensation of apparent size exists at long distances. At the distances used by Brunswik (1944) it was great; apparent size was only beginning to decrease from complete constancy.

Variations of size constancy with age are also affected by the conditions in which it is studied experimentally. Thus in experiments by Beyrl (1926) and in some of those of Burzlaff (1931), the standard and a single variable were presented for paired comparison. Constancy was found to be less for the younger children (aged four years) than for the older (aged seven years). This was attributed to a tendency on the part of the younger children to be affected by previously presented variables. But Piaget and Lambercier (1943a) first studied the results obtained by children (aged five to seven years) and by adults in comparing the heights of pairs of stakes when these were equidistant from the observer, though at varying distances from each other. Afterwards they studied the comparison of the heights of the same stakes at different distances from the observer (1943b). They concluded that two tendencies were at work, operating differently in adults and in children: (1) A tendency, operating both in adults and in children, to over-estimate the standard by comparison with the variable, whenever these were spatially separated to such an extent that they could not be seen at a single fixation. This was due to the general tendency to measure the less stable parts of the situation (the variables) in terms of the more stable (the standard); hence the latter assumed a privileged status, and its height was over-emphasized and over-estimated; (2) children tended to under-estimate the farther object, and thus to show a size constancy of less than 1·0; this agrees with the results of Beyrl and Burzlaff. But adults tended to over-estimate the more distant object, and hence to show a size constancy of more than 1·0. The explanation for this latter tendency given by Piaget and Lambercier is that adults will centre their awareness upon the more distant object, hence bringing it forward in space and making it appear relatively larger. This explanation does not seem very convincing. But it is possible to explain the actual findings of Piaget and Lambercier in terms of the conflict or reinforcement between tendencies (1) and (2). Moreover, the results agree with those of Akishige (see Lambercier, 1946a), who found that in adults there was a tendency to 'over-constancy', that is, constancy greater than 1·0, when the standard was farther away than the variable; and a tendency to 'under-constancy', that is, constancy less than 1·0, when the standard was nearer than the variable.

Different results again are obtained if the variable, or both the variable and the standard, are presented as members of a continuous series of magnitudes. Burzlaff (1931) found then that constancy was more or less complete whatever the age of the observer. But Lambercier (1946a) found that the constancy of children is equal to that of adults only when the correct variable for constancy (that actually equal to the standard) is the median of a series. If a series of variables is presented such that the 'real' size of the median is greater or less than that of the standard, then constancy will be greater or less than 1·0—because the child shows a 'central tendency of judgement' and will be liable to match the standard with the median of whatever series is presented to him. Adults are less susceptible to this bias.

On the whole, young children, according to Lambercier (1946b), are unable to make good use of a framework of reference created, as described on p. 123, by introducing subsidiary objects between the standard and the variable. They tended either to compare standard and variable directly, ignoring the framework; or to compare the variable with one of the pieces of the framework, ignoring the standard.

Lambercier (1946b) concluded that in making accurate judgements of size relationships, it was necessary to isolate intellectually and perceptually those elements which were relevant to the particular type of judgement. Thus previously presented variables, and the number of variables on either side of the one equal to the standard, must be ignored. But subsidiary objects should be utilized in the light of their relationship to the standard (greater, less, or equal) for assisting judgement. This required first an intellectual deduction as to the relative sizes of the various objects; and then an actual perceptual comparison of the appropriate ones, together with the ignoring of the irrelevant ones. Thus the type of immediate perception described above does not in general occur in laboratory surroundings, but is replaced by intellectual judgement, more adequately performed in so far as the relevant configurational relationships are deliberately observed and utilized. Immediate perception of constancy operates only when the perceptual situation is a very simple one, as in experiments with animals, or in the spontaneous activities of young children, or in the 'snap' judgements made by adults in natural surroundings, as shown by Brunswik (1944). But that even the simplest type of size constancy has to be learnt by experience is indicated by the experiments of Brunswik and Cruikshank with infants; and by an experiment of Akishige (see Lambercier, 1946a). He found that the size constancy of two children of nine years, born blind but given temporary vision by means of a mydriatic, was only 25 per cent of their degree of brightness constancy; whereas in the normal individual size constancy is usually greater than brightness constancy.

The difference between immediate perception of constancy and deliberate intellectual judgement about it was further demonstrated by Stavrianos (1945), who found that under normal conditions judgement of shape and angle of tilt were, contrary to the findings of Eissler (1933), more or less independent of one another; the shape was assessed by 'implicit registration'—or guesswork; the angle of tilt by 'explicit judgement'—or measurement. With monocular vision, 'explicit judgement' was used for shape also, and hence was found to be closely related to judgement of tilt. These two types of judgement parallel the two described by Joynson (see p. 125) in judging size constancy—immediate impression of the size of the 'real' object, and estimation of proportion of the field occupied by the object.

It is clear, therefore, that the degree of constancy varies in adults according to the nature of the deliberate judgements which they make. Numerous experimenters have shown that the size of the indices of constancy or phenomenal regression varies between different individuals, and with different attitudes. The usual effect of the analytical or 'stimulus' attitude (directed towards the sensory aspects of the stimulus object) is to diminish the indices. This was found by Klimpfinger for shape (1933), and by Holaday for size (1933). Thouless (1932) also found that artists, who presumably adopted the analytic attitude, had relatively low indices of phenomenal regression for shape. Henneman (1935) found greater constancy for those who adopted the 'object' attitude than for those who adopted the 'stimulus' attitude; but these attitudes were unrelated to the amount of psychological training of the observers. Sheehan (1938) found that there was little correlation between the size of the indices for whiteness, shape, and size, indicating that the attitude might vary from one situation to another. Locke (1938) found a bimodal distribution, which he considered was related to differences of intelligence rather than to differences between analytic and synthetic attitudes. Thouless, in contrast to Sheehan, found that the indices of phenomenal regression for size, shape, and whiteness did show significant correlations (1932); and that their pooled results showed a small but statistically significant negative correlation with intelligence test scores.

The factors determining the compromise between the sensory impression and the cognition of the object have been rather differently presented by Brunswik (see Tolman, 1935). He found, as in the experiments described above, that if the observer is instructed to select an object which 'looks' the same size as another nearer object, the one chosen will be slightly larger than the nearer object. But if he is instructed to select one which looks as if it would project the same sized retinal image as the nearer object, a much larger one is selected. In both cases, the value attained is displaced from its 'pole' ('real size' or 'retinal image size') by the action of the alternative 'pole'. However, with the 'object' attitude the 'real size' pole has the stronger pull, because the sensory cues to 'retinal size' are mainly ignored. With the 'sensory' attitude, the other pole is stronger because the sensory cues to the distance of the object are mainly ignored. But errors may occur because the groups of sensory cues are not always unequivocally related to particular objective values. Further, as Tolman and Brunswik (1935) point out, it seems that the organism cannot correct its use of inappropriate or misleading cues, but must resort to discursive thought and the formation of further hypotheses as to the nature of the situation. The hypotheses must then be transferred from the general case to the particular situation, and the organism learn to respond to some partial cue, in the light of all the other cues afforded by the situation.

The probable conclusion is that the immediate perceptual impression of constancy in surroundings which provide an adequate configurational setting is strong with the more immature, primitive, and unanalytical type of mind. But if rather different and accurate judgements are required, with little immediate, or with only indirect, assistance from the configurational setting, then greater constancy appears to be attained by the intelligent adult, always provided that he adopts the 'object attitude'—that is to say, that he tends to answer 'yes' when asked a question such as 'Is this object the same size, shape, or colour as that?' But let him obtain the impression that he must make an exact quantitative comparison of relative size, shape, or colour, and he will be liable, particularly if highly educated or of an analytical turn of mind, to adopt the 'stimulus attitude'; and his constancy will be less than that of the more primitive or immature individual who is innocent of all such subtleties. But we may suppose that, in ordinary everyday life, both child and adult pay more attention to what things 'are' (the 'real' object) than to what they 'look like' (the retinal image), because in general what they 'are' is more important than what they 'look like'. Thus it seems that schemata of relationships have been established between the varying shapes, sizes, brightnesses, and colours of objects, and their varying positions and illuminations in space, with a view to producing constancy of appearance in objects which retain a constant identity, together with some apprehension of the variations in position and illumination. But the individual may, when he is said to adopt the 'stimulus attitude', deliberately 'turn round on his schemata' (see Bartlett, 1932) and use other criteria of judgement. This is not really so much a matter of attitude in the usual sense of the word, as of a purposeful direction of awareness to features in the environment which had previously been ignored. The ordinary untrained individual is not always skilful in focusing his awareness in this way; trained as an artist or a judge of coloured fabrics, for instance, he may do better.

But we seem to be no further forward in explaining just how by a differentiation into 'figure' and 'ground' a single retinal impression is analysed into the phenomenal qualities inherent in the object, and those supplied by the framework. Clearly the extent of the differentiation varies within certain limits according to what the observer is looking for; but yet it is hardly ever complete, no matter how uncritical his attitude. It cannot be held to result from some rigid 'all-or-none' process, such as Koffka's theories might lead us to suppose. To say that there is a schematic organization of series of changes in stimulus qualities with corresponding series of changes of phenomenal qualities, is to give a description but not an explanation. Moreover, if this organization were really efficient, one might suppose that the appearance of the object would remain completely constant, which we have seen is not so, particularly in illumination of changing colour and intensity. Yet when variations in size, shape, colour, or brightness are actually perceived to have occurred, the object may still retain its phenomenal identity, unaffected by these changes in its appearance. But again, it does not always do so; a building, for instance, may be hard to recognize when seen from an unfamiliar angle or distance.

With all the knowledge which has been gained of the phenomenology of the 'constancies', there is no satisfactory explanation of their method of operation.

CHAPTER VII

THE FUNCTIONS OF THE FRAMEWORK IN PSYCHO-PHYSICAL EXPERIMENTS

(1) THE INDIFFERENCE POINT AND THE CENTRAL TENDENCY OF JUDGEMENT

We must now devote some attention to considering a mass of data relating to the type of 'constant' errors that occur in psycho-physical experiments. By 'constant' errors we mean those which constantly occur in the same way, and are not mere chance variations. At first sight this problem may appear highly esoteric and remote from everyday life. But further examination seems to show that in fact it constitutes one more example of the attempt to cope with an unfamiliar situation involving a particularly difficult type of judgement by employing all previous relevant experience as a framework to which the present perception may be anchored, and by means of which it may be stabilized.

In the last chapter we mentioned the 'central tendency of judgement' shown particularly by children in making size judgements—that is, the tendency to equate the median of a series of variables with the standard, no matter what the actual range of variables presented. This central tendency resembles that which has long been known to exist in psycho-physical measurement—the tendency of constant errors in judgement to distribute themselves about some central point usually called the 'indifference point'. Thus Warren and Shaw (1895) showed that in estimating the size of squares, one at the upper end of the series of magnitudes presented was under-estimated, and one at the lower end was over-estimated. That is to say, the indifference point, where there was no constant error in either direction, tended to fall somewhere towards the middle of the series. A great deal of evidence has also been obtained using non-visual material. We shall include some of this, since the problem is similar for all classes of stimuli. Thus Hollingworth (1909) showed the existence of the indifference point for hand-and-arm movements of different lengths. He used three different series of lengths, and in each case the indifference point was situated approximately at the centre of the range of that particular series. Yet cases do seem to occur when, if the effect of a particular range of stimuli is eliminated, an absolute indifference point may appear. Thus Woodrow (1930) found that no evidence could be obtained of any constantly located indifference point in the reproduction of intervals of time for the same individual reproducing a series of time intervals, even when he worked with only one series on one day. But if a different group of observers was used for each interval, the indifference point was found to be located fairly consistently at a value of 625 σ (1934). That is to say, those who reproduced time intervals of less than that amount consistently over-estimated them, and those who reproduced greater intervals consistently under-estimated them. Thus when all influence of a 'level' fluctuating with the range of stimuli was eliminated, a 'level' was discovered which was relatively persistent and consistent in a number of individuals, and was presumably based upon some general underlying tendency.

The same type of distribution about a central point as demonstrated by Hollingworth is found to exist when the observer is asked to make absolute judgements of size or intensity, without the use of a comparison standard. The distribution of these judgements again seems to be based partly upon the range of stimuli which occurs in the experiment, and partly upon more general and persistent impressions derived from previous experience. The existence of these absolute judgements was demonstrated in the discovery that, in making comparative judgements between pairs of stimuli, if the second member of the pair was not presented for an appreciable interval of time after the first, the observer would base his comparison in part upon absolute judgements of the magnitude of each of the stimuli. This was noted by Bentley (1899) with series of greys, by Angell and Harwood (1899) with tones. Martin and Müller (1899), again, with weight lifting, found the tendency to use an absolute impression of heaviness or lightness of the stimulus, based apparently upon experience in everyday life of lifting light and heavy objects. The experiments of Nahm (1932) also appeared to show the existence of an absolute impression of size which affected relative size judgements. Wever and Zener (1928) again showed that observers were able to make mutually consistent absolute judgement of 'heavy', 'medium', and 'light' in a series of singly presented weights.

This scale of judgements, however, appeared to sink gradually during the course of the experiment. A gradual increase was observed in the number of judgements of 'heavy'; that is to say, there was apparently a constant tendency for the absolute series to move downwards in the intensity scale, a gradual sinking of 'level'. If, however, a series of much heavier weights was suddenly introduced, for a few rounds of presentations the majority of the latter were judged heavy; but in time they also became distributed more or less equally as to 'heavy', 'medium', and 'light'. Thus the 'level' was easily modified by a sudden change in the character of the stimuli, but in time returned more or less to its previous value. Results of a similar type were obtained by Pratt (1933a). He required his observers to grade a series of sounds, given without a standard, into nine grades of loudness. Shortly afterwards a second series was given consisting entirely of sounds of less intensity than those of the first, and the observers required to judge as before. In the first series there was a tendency to give a larger number of estimates of high intensity than of low; that is to say, there was a massing of judgements above the medium point. But in the second series, the opposite tendency was at work, and more judgements of low intensity were given than of high. In the first series, the absolute standard tended to sink to a lower 'level'; in the second, it was determined rather by the stimuli of the previous series than by the general 'level'.

These results were supplemented and confirmed by Needham (1935a), with series of three or four singly presented tones. In the series at the most intense level (60 db.), there was a tendency to give a larger proportion of 'loud' than of 'weak' judgements; and in the series at the least intense level (20 db.) there was a tendency to give a larger proportion of 'weak' than of 'loud' judgements. Thus some type of absolute 'level' or indifference point was at work here, tending to increase the proportion of 'loud' judgements at high intensities and of 'weak' judgements at low intensities. But a contrast effect to previous stimulation could also be demonstrated. If the more intense series was immediately preceded by a less intense, the proportion of 'loud' judgements in the former was increased; and if the less intense series was preceded by a more intense one, the proportion of 'weak' judgements in the former was increased. But this modification of 'level' produced by stimulation tended to disappear fairly rapidly. For towards the end of a series, the effect produced by the preceding series passed off, and the distribution of 'loud' and 'weak' judgements returned to the normal as determined by the absolute indifference 'level'.

Tresselt (1947) produced evidence to show that in all probability the establishment of *absolute* judgements was largely a result of long practice. She required her observers to judge as 'heavy' or 'light' the weights in a preliminary 'practice' series, and then gave them an extended series of weights to judge. There was a tendency at first to relate judgements of 'heavy' or 'light' in the latter series to the central point of the 'practice' series. This tendency gradually disappeared; but the greater the amount of the preliminary practice of the 'practice' series, the longer the time taken for its effect upon the extended scale to disappear. One observer who carried on the lifting of heavy weights as a constant recreation continued to judge all the weights of the extended series as 'light'. Thus we may conclude that our normal everyday judgements of magnitude are largely determined by the magnitude of stimuli with which we are accustomed to deal. In the case of weight lifting, the limits of 'heaviness' might be constituted by the heaviest weights we could lift, and the limits of 'lightness' by that weight which first produces an appreciable sensation of weight when it is lifted. There would be a long range of intermediate weights between these two, with its central or indifference point somewhere in the middle. Clearly the range of anyone who was in the habit of lifting very heavy weights would be extended in the upward direction, and with it his central or indifference point. Clearly also a temporary shift of this point could be produced by practice, and the greater the amount of practice, the greater the permanence of the shift. But the amount of possible shift appears to be limited in extent by an absolute range of the nature of that described above. Thus Rogers (1941) carried out experiments in which individuals, presented with a series of six weights given singly, were required to place them in six categories of heaviness, the nature of which he had to work out for himself. After he had done this successfully, he was given, just before each stimulus of the series, an 'anchoring' stimulus which he was told constituted category 'six' of weight. At first this anchoring weight equalled the heaviest weight of the series of six. It was then made progressively heavier, and the result at first was that the observer reallocated his categories of heaviness accordingly, shifting them regularly downwards as the anchoring stimulus was made heavier. But after a time the observer discontinued his regular shift downwards; he began to neglect the anchoring stimulus, and tried to use other schemes of allocating his categories. Thus we must allow that the indifference point is always determined to some extent by an established framework, and cannot be shifted from this framework to more than a limited extent.

(2) THE TIME ERROR

What we have said so far refers mainly to psycho-physical judgements of series of stimuli in relation to the rest of the series. But the same type of relationship appears to operate when stimuli are presented for comparison successively, in pairs. It was found by Fechner (1860) that there is a constant error in comparison of pairs of stimuli which is related to the lapse of time between the presentation of the first stimulus and of the second. Sometimes the first of the pair is relatively over-estimated, in which case there is said to be a 'positive time error'; more commonly, the second is relatively over-estimated, showing a 'negative time error'. Moreover, in general the negative error increases in size as the interval of time between the presentations increases. This tendency was found by Fechner

(1860) in weight lifting, by Wolfe (1886) with tones, by Lehmann (1889, 1891) with tones and brightnesses, by Warren and Shaw (1895) with sizes of squares, by Angell (1900) with clangs and with shades of grey. Bentley (1899), also working with different shades of grey, found that when the grey discs were shown in the daylight, with an interval of daylight between presentations, the second disc appeared lighter than the first; but if they were shown in comparative darkness, the second appeared darker.

These experiments were repeated by Köhler (1923) with auditory stimuli. He found that if a sound of a certain intensity was followed after an interval of silence by one of the same or less intensity, there was usually a positive time error if the time interval was three seconds or less, but an increasingly greater negative error as the time interval increased above three seconds to a limiting value of twelve seconds. Lauenstein (1932) repeated these experiments and confirmed these results, and also studied the effect of giving a much louder sound during the interval. In this case the second sound stimulus appeared increasingly less loud than the first as the time interval increased. The same effect was obtained with visual stimuli.

To explain his results, Köhler (1923) advanced his theory of 'traces'. This postulates that the excitation from the first stimulus results in a gradual accumulation of H ions in the cortical field; and the 'trace' of this accumulation left at the time of the second stimulation is compared with the excitation from the second stimulus. The accumulation of H ions increases for a short period after the first stimulation, and then becomes gradually dispersed. Consequently the second stimulus will appear at first less by comparison with the trace of the first stimulus; but after a short time will appear greater, and continue to increase by comparison, up to a limiting value. Lauenstein (1932) modified this theory, explaining the effects by an assimilation of the trace towards the ground. If the ground is darkness or silence, the trace decreases, and the second stimulus is overestimated. If the ground is a more intense sound or light, the trace will increase, and the second stimulus will be under-estimated by comparison—as was shown in Lauenstein's experiments.

Woodrow (1933) has pointed out certain difficulties in the way of Köhler's theory. Thus supposing a very intense stimulus is given before the pair of stimuli to be compared; the trace left by the preliminary stimulus will completely overshadow that left by the first member of the pair; and the second member of the pair will be compared with this trace. It should appear much less than the first trace, and should therefore be reported to be less than the first member of the pair, even though it actually exceeds it in intensity. Woodrow points out that on this theory a weight of one hundred grams might be judged less than one of fifty grams, if a weight of two hundred grams had been given shortly before the one of fifty grams, which result has never been reported in practice.

Woodrow, rejecting Köhler's theory, does not adopt instead the Aristotelian theory of the persistent memory image, produced by the first member of the pair and compared with the second, since no sign of such an image is usually reported introspectively. He prefers the concept of 'set' or attitude, aroused by the presentation of the first member of the pair, which persists and affects the observer's judgement of the second member. This 'set' constitutes a kind of mental standard, such as Fernberger (1931) has postulated to exist generally in the making of psycho-physical judgements. We shall discuss this type of 'set' more fully below. Here, it should be noted that the 'set' or 'mental standard' which we are discussing is based upon categories of 'heavy' and 'light' evolved by the observer himself during the course of the experiment, thus resembling those described in the first section of this chapter. Therefore when a long series of stimuli is presented, a framework is created by these series with an average 'level'. At any given moment, however, the 'level' is most closely associated with the immediately preceding members of the series. When the first of a pair of stimuli is presented, the 'level' at that moment approximates to the value of that stimulus; but as time goes on, the 'level' tends increasingly to approximate to the average 'level' for the whole series. Hence the second member of the stimulus pair is more and more liable to be compared, not with the first member of the pair, but with the average 'level' of the whole series. Again, the 'level' is suddenly raised by an unusually intense stimulus, and lowered by an unusually weak one; and hence there is a negative time error after a stimulus above average intensity, and a positive time error after a stimulus below average intensity. Consequently if a variable standard is used in weight-lifting experiments, the time order error varies irregularly from positive to negative, as was actually demonstrated by Woodrow (1933). Finally, this 'level' all the time tends to sink to a lower 'level', but does not approach zero as long as the observer is expecting the presentation of stimuli; when this occurs, however, the 'set' disintegrates, and the 'level' falls back to some normal or habitual one.

Pratt (1933a and b) would use the term 'trace' to indicate merely a persistent after-effect of some kind produced by the effects of stimulation, without offering any theory as to its exact psychological or physiological basis. He rejects Lauenstein's conception of assimilation since the tendencies implied by it seem to operate only in very special cases, as when the ground or 'level' is a sound louder than the stimulus sounds. He prefers to postulate a gradual sinking of the 'level' except when it is modified by the stimulus series actually in use, as shown in his own experiments which were described above. He also showed that the negative time error was greater if a weak sound was interpolated between the two stimuli than if no such interpolation occurred (1933b). According to Lauenstein's theory, however, the time error should have been less negative, since there would be less assimilation to a ground containing some sound than to a ground containing none. In a later paper, Pratt (1936) advances the explanation that the standard sound and the empty ground of silence belong to two partly different trace systems, which therefore interact less with each other than do the standard and the interpolated weak sound. He also found that a heavier weight lifted just before the standard merely reduced the size of the normal negative time error, rather than producing a large positive time error, as it should on Lauenstein's theory. Guilford and Park (1931) obtained the same effect when the heavy weight was interpolated between the standard and variable. Thus Pratt considers that there is always a weakening of the trace of the standard, producing the negative time error.

Further results unfavourable to the physiological theory of accumulated H ions have been advanced by Needham (1934). He repeated Köhler's sound experiments and found that, although his results in general agreed with Köhler's, yet some of his observers did not show a gradually increasing negative time error with increasing time interval; but the error decreased again with intervals of four to eight seconds, and thus seemed to fluctuate periodically. Again, Köhler had found that the time error curve changed markedly with repeated practice in performing these experiments; and had suggested that the positive time error might persist with longer time intervals, while the negative time error was correspondingly postponed and decreased. Presumably this would result from a gradual increase with practice in the accumulation of H ions. But Needham found that with practice the effect was completely reversed; the time error was negative for short intervals, up to two seconds, and after that positive. However, a later experiment by Needham (1935b) tends to confirm Köhler's results rather than Needham's earlier ones. This experiment was carried out by the method of single stimuli. Four tones differing in loudness by 1 db. were presented singly at intervals of four, six and a half, or fourteen seconds. The number of judgements of 'weak' decreased with increase of time interval, and the number of judgements of 'loud' increased. This result is parallel to the increase in the negative time error with increasing time interval. Moreover, after practice the number of 'loud' judgements at four-second intervals increased, and the number at fourteen-second intervals decreased, which corresponds to the decrease of the negative time error with practice. Later experiments have again thrown the whole matter into doubt. Koester (1945) found constant errors in judgement of loudness, but these appeared to be related only to the absolute impression (being positive at lesser intensities, negative at louder ones). They showed no systematic change in size or direction with increasing time interval. But Postman (1946), using three standards of 35, 55, and 75 db., found a time error which was decreasingly positive up to a time interval of two seconds, and after that increasingly negative. Work by both Koester (1945) and Postman (1946) on judgements of pitch showed no significant variations of the time error. This is, however, to be expected since the differential threshold for pitch is itself a labile phenomenon. However, the work of Koester and Schoenfeld (1946) seemed to show that pitch judgements were affected by a central tendency of judgement, especially with naïve observers, and when the inter-pair time interval was long.

Woodrow (1935) obtained a further set of results agreeing with those of Köhler. In these he used time intervals as stimuli. A long series of comparisons of pairs of unfilled time intervals was carried out; the intervals were silent and were bounded by momentary clicks. Each pair consisted of a standard interval, 1000 σ in duration, and a variable of 800, 900, 1000, 1100, or 1200 σ. In some cases the variable preceded the standard, in others it followed it; in each case there was an interval of two seconds between the two members of the pair. It was found that at the beginning of the series the time error was negative in all cases; but as the series proceeded, there was a gradual shift in the positive direction—with the shorter variables the error became positive, and with the zero difference and longer variables it became less negative. The series was repeated on subsequent days, and the positive effect, though in each case less at the beginning of the sitting than at the end of the previous sitting, became increasingly positive before the end of the sitting. This effect was shown to be independent of any increase in acuity of comparison produced by practice.

Woodrow explained his results, and those of Köhler and Lauenstein, in terms of two 'levels': (1) the absolute standard or indifference 'level'—which he had already shown to be about 600 σ for unfilled time intervals (see p. 150); (2) the standard provided by the average of all the previous stimuli in the series—in this series, 1000 σ. The impression produced by the first member of the pair tends to sink or gravitate towards one of these 'levels'; and the second member of the pair is then compared with this modified impression. In the early stages of practice, the effect of the absolute indifference 'level' is stronger than that of the average of the series, since there has been no time for the erection of a standard based upon the latter. Thus the impression tends to sink to the lower 'level' (600 σ), and the time error is consistently negative. In the later stages of practice, the average standard has been more firmly built up, and exerts an increasingly strong influence which even persists from one day's practice to the next. Consequently the impression of the first stimulus tends to assimilate towards the higher level (1000 σ), and the time error tends to become positive.

Both negative and positive time errors can thus occur with the short intervening interval of two seconds which was used by Woodrow. This result contradicts that of Köhler, who made the variable effect of a varying time interval one of the important factors of his theory. Woodrow suggests that Köhler's results were perhaps due to his use of an asymmetrical series with the variables all less than the standard. His positive errors with these smaller variables and pauses of less than three seconds may have been due to the tendency to gravitate towards the average standard which would be relatively more potent with short pauses than with long pauses. For during the longer pauses the average standard, which would be relatively unstable compared with the absolute indifference 'level', might tend to distintegrate and become less potent. Thus with long pauses the impression would always tend to gravitate towards the absolute indifference 'level', and the error would always be negative.

Whether or not this is the correct explanation of this particular effect of Köhler's, there is no doubt that Woodrow's theory of the two standards operating with different potency at different stages of practice seems to afford a plausible explanation of many of the results which we have described in this section. As to the nature of the average standard, Woodrow offers little explanation; presumably it is some kind of mental 'set'. The absolute indifference 'level' may be a purely mental phenomenon, built up as a schematic memory from past experience; or it may be innate in origin, based upon some type of adaptation of the nervous system to respond most readily to two momentary stimuli which succeed one another at an interval of 600 σ. If the interval be filled by tonal stimulation, presumably this most favourable interval is increased to 900 σ; for Stott (1935) has shown that the indifference point lies at about 900 σ for the comparison of tonal intervals.

But it is of course very possible that the nature of the framework or standard may be considerably clearer in the case of stimuli which possess a clearer and more obvious objective basis. Several experiments have been carried out on the time errors which occur in the comparison of magnitude of visually presented stimuli. These show that, as might be expected from the results described in previous chapters, the magnitudes of the stimuli are judged with respect to the spatial framework in which they are situated. Thus Crannell (1941), using the comparison of the distances between pairs of dots projected on a screen, obtained a negative time error; but Marchetti (1942), using comparison of black lines projected on a screen, found a positive time error in every case. McClelland (1943) suggested that Marchetti's results were due to 'assimilation' of the traces of the lines to the outline of the card on which they were drawn. He himself presented bright lines in a darkened room, and obtained a negative time error. However, on further experiment it appeared that this might be due to the gradual fading of the light of the standard line, producing an impression of inward movement of the ends of the line (γ movement, see p. 175); that is to say, the actual sensory impression decreased in length, not merely the trace of it. When the light was cut off suddenly, a positive time error was found, but smaller than Marchetti's. Hence it seemed possible that some assimilation to the framework was functioning in Marchetti's experiments.

Tresselt (1944) concluded from her experiments that when the test objects and the background were heterogeneous in form, a negative time error resulted. When they were more or less homogeneous, or closely attached to one another, there was a negative time error if the background was smaller than the test objects, a positive error if the background was larger. It was further suggested by McClelland that even when the framework is not actually visible, it persists as a spatial schema towards which assimilation may take place. In fact, it operates much as the schematic scale of impressions of 'heavier' and 'lighter' operates in weight-lifting experiments. In all these cases, the time error seems to be modified by virtue of the observer's comparison of the second stimulus with a schematized set of impressions, constituted in part by the perception of the first stimulus, and in part by all other related stimuli, either past or present.

To sum up, therefore, we may state that these experimental data indicate that it is difficult if not impossible to abstract particular sensory qualities from the total perceptual setting, even when every assistance is given in keeping that setting constant. The individual will still relate these qualities to some framework or schema resulting from his background of experience of similar situations. Different individuals are affected in this way to a different extent, as we shall see in Chapter X. But the irregularities and inaccuracies which appear in psycho-physical judgements can usually be traced back to the influence of some type of framework or schema which may be visual, kinaesthetic, tactile, auditory, or temporal, in accordance with the demands of the present situation. Again the function of the schema is the stabilizing of impressions, and of rendering them more manageable in terms of everyday life experience.

CHAPTER VIII

THE PERCEPTION OF MOVEMENT

(I) REAL MOVEMENT

We have already noted that we usually assume that objects around us remain stationary unless we perceive them to move in some familiar and recognizable way. Change of position does of course occur without any actual perception of movement being possible; but usually this is associated with certain characteristic and well-known phenomena such as the growth of plants, the rise and fall of tides, the movement of the hands of the clock, and so on. We shall see that in some respects the perception of change of position obeys the same laws as those which govern perception of movement. Nevertheless, it also appears that movement is a phenomenon *sui generis*. Its perception is schematized and reacted to in certain characteristic ways which have no doubt developed with experience, yet nevertheless seem to be to some extent spontaneous and innate. The characteristic movements of objects are organized within and related to the general spatial framework in somewhat the same way as are the relative distances and separation of stationary objects. We have already pointed out, in Chapter v, that, whenever there is any movement in the field, whichever part of the visual field is taken as framework tends to appear stationary, while that part which is taken to be 'figural' appears to move. The schemata into which we organize our visual experiences tend then to allow for smallish objects moving across a steady background—and such of course is our usual experience of events in the surrounding world.

There seems to be some evidence to show that both phylogenetically and ontogenetically the perception of movement may develop very early as a process distinct from the perception of stationary forms. Gesell *et al.* (1949) observed that even the prematurely born 'foetal' infant showed some awareness of moving objects. Thus movement was linked in primacy with bright light. An infant of four weeks could follow the movements of a dangling ring fairly closely with his eyes through an angle of 90 degrees. In the second quarter of the first year the eye movements had become smooth, accurate, and prolonged through 180 degrees. At about thirty-six weeks he showed considerable interest in movement as such, and appeared to compare the different types of movement he perceived.

Again, Riddoch (1917) has shown that as recovery proceeds in cases of injury of the occipital cortex, the first types of visual stimulus to be perceived are bright light and movement. Furthermore, although the threshold for movement perception (both for least perceptible speed and for least perceptible distance covered) is actually lower in the fovea than in the peripheral retina, yet form perception is so dim and blurred in the periphery that moving objects appear with relatively greater clarity than do stationary ones. Hence the impression of movement as such, without perception of the object moving, is a characteristic experience in peripheral vision. Such a movement 'catches our attention' with extreme rapidity, and we immediately respond by turning the eyes and the head in order to focus the eyes on it and see it clearly. The usefulness of this as a danger reaction is obvious. And we shall bring forward evidence in Section (2) of this chapter to indicate that movement as such may be an experience *sui generis*, irrespective of what is moving.

Until recent years, the phenomenology of movement perception had received curiously little attention. But in the last few years Michotte has carried out a very extensive series of experiments on this subject. Since, however, the majority of his conclusions deal with the relation between movement and causality, their discussion will be postponed to the next chapter. Here it may be mentioned simply that quantitative differences of speed and direction of movement may produce quite different qualitative impressions of type of movement. Some part of the work of Brown (1931c) and also of that of Metzger (1926) was devoted to determining the thresholds of velocity between the perception of change of position and of movement, and between perception of movement and of partial fusion of the moving objects to produce the impression of a continuous band of flickering light. These threshold values were found to depend on the formal qualities of the field. The lower of these two thresholds was found by Brown (1931c) to vary in magnitude with the structural properties of the field. It was lowered with decrease in size and brightness of the moving objects (raising of phenomenal speed), and with increased inhomogeneity of the field. Metzger (1926) found that the critical speed for fusion was also lowered with a decrease in size and brightness of the objects. For speeds at other than threshold values, Brown (1931a) found the same relationship between phenomenal speed and the structural properties of the field. If all the linear dimensions of the moving objects and of the field across which the objects moved were transposed, for instance doubled, then the phenomenal velocity was transposed in the opposite direction, in this case halved. And the actual velocity had to be doubled to make the perceived velocity appear equal to a standard velocity with which it had previously been equated. But if the distance of the moving objects from the eye was changed, the apparent velocity remained almost constant, though not quite as constant as does apparent size; the apparent velocity did decrease slightly. Phenomenal speed resembles phenomenal size in another respect: it is greater in the vertical than in the horizontal direction, to correspond with the apparently smaller size of objects seen vertically than of objects seen horizontally.

Brown (1931b) pointed out that these changes in phenomenal speed with change of structural factors must be due to change either of phenomenal time or of phenomenal space. Since the phenomena seem to parallel the size constancy phenomena, one might suppose the second to be the more probable cause. Brown, however, says that variation in phenomenal time is more frequent than is variation in phenomenal space; and it is certainly true that phenomenal time is far less stable, because it has so little objective reference, than is phenomenal space. But Cartwright (1938) considers that changes in phenomenal space, along the lines of Weber's Law, are responsible. He found that if observers were required to indicate the changes in position of a dot which would be necessary to bring it to the centre of a field framed by an aperture, then the errors of localization were more or less proportional to the dimensions of the field. This parallels Brown's result that the threshold for velocity and the phenomenal velocity were proportional to the dimensions of the field. Hence Cartwright concluded that no awareness of time is involved in the perception of change of position, and therefore that it must play comparatively little part in perception of speed and change of speed. Now it seems very probable that errors in estimation of speed would obey Weber's Law, just as did errors in estimation of position. But it by no means follows that the actual appearance of speed must be governed by the same principles. As we shall see, however, in the next sections, it is extremely difficult to reduce the characteristics of movement and speed of movement to terms of its physical constituents, space and time—probably for the reason mentioned above, that we are aware of movement long before we can analyse it into these constituents. Thus the 'appearance of movement' will vary qualitatively and be influenced by a number of psychological factors unrelated to space and time.

Piaget (1946) found that young children estimate the extent and speed of movement with considerable uncertainty, and do not assess it with quantitative accuracy until they have reached the age of nine to ten years. In the first place, the younger children seem to be much influenced in their judgements by the qualitative nature of the movement. Thus children of six to seven years were apt to say that an ascending movement 'went farther' than did a descending movement of equal extent, apparently because ascending movements, of, for instance, a funicular railway, created an impression of greater effort. Again, if two objects moved in the same direction, one along a straight path, the other along a very crooked one, and the child was asked to make the first 'go as far' as the second, he usually stopped the former at a point opposite to that at which the latter had been stopped, regardless of the difference in length of the two paths. Here he was influenced by a single aspect of the situation, and did not analyse it out and take into account all its constituent factors. He also had great difficulty in understanding relative movement, when, for instance, an object moved on a sheet of cardboard which also moved. The extent of the total movement of the object was not accurately estimated until nine to ten years.

By children up to six to seven years of age, speed was assessed also from a single aspect of the situation, and not from an impression of speed as a whole. One object was judged to move faster than another when it could be seen to pass it. They took no account of the perceived speed, nor of the starting and finishing points, nor of the actual paths covered. If two objects did not pass, but arrived at the same point at the same moment, they were judged to have equal speeds, no matter when they started, nor what distances they covered. The judgement was thus centred on the single spatial element of the finishing point. Again, if two objects were made to rotate through concentric circles of different diameter in the same period of time, children of six to seven years said at first that their speed was the same, because each arrived at the point of departure at the same moment. When it was pointed out to them that the object moving round the outer circle had a longer distance to cover, they might then say that the object moving round the inner circle moved faster because '*il a moins à faire*'. A clear realization of the relation of speed to distance covered was not in general gained until eight to nine years of age. Now this of course was based upon an analytic judgement as to the relation between distance and speed. It is possible that, had the speeds compared been exceedingly different, the child would have perceived the correct relationship directly. Moreover, the fact that direct impressions are to some extent utilized in simultaneous comparison of speeds seems indicated by the further results of Piaget showing that judgement of speed of successive movements was even more vague and inaccurate than that of simultaneous movement. However, it must be concluded from the above results that the direct impression of speed is not at all clear or definite, and is not used spontaneously by the child in comparing speeds which are not greatly different from each other.

(2) APPARENT MOVEMENT

If comparatively little study has been made of the phenomenology of real movement, this omission has been amply compensated as regards the apparent movement phenomenon—the appearance of movement when no object is actually in motion. This was one of the first phenomena to be studied by the Gestalt psychologists, and a vast amount of work has been devoted to it, extending up to the present day. This work may perhaps be considered to be out of all proportion to the importance of the phenomenon as such, since it occurs comparatively infrequently in ordinary life. It is most familiar to us in the stroboscopic movement of the cinema. But many of the Gestalt principles have been based on results relating to apparent movement. These results have been controverted by other experimenters, who have brought forward rival theories. It seems unnecessary at this juncture to describe all this work in detail. Neff (1936) has done this admirably. Therefore certain earlier studies will be merely summarized, and a rather fuller treatment given to more recent work. In particular, Dimmick's theory of the 'grey flash' (1920) is omitted, since most other experimenters have found it to be unimportant or absent.

The basic experiments were carried out by Wertheimer (1912). He showed that if two stimuli were exposed successively in different spatial positions, then in favourable conditions the observer might perceive a single stimulus object moving from the position of the first to that of the second. This Wertheimer termed the 'phi phenomenon'. When there was an impression of movingness without any awareness of the object which moves, then it was called the 'pure phi phenomenon'. Wertheimer found that if the second stimulus was exposed for an appreciable interval of time before the first stimulus disappeared, both stimuli were seen separately and simultaneously. If the second was exposed at an appreciable interval of time after the first had disappeared, both stimuli were seen separately and successively. If, however, the second stimulus appeared at about the same moment that the first disappeared, then the first appeared to move right across the field from the position of the first to the position of the second. This was called 'optimal' movement or full movement. On other occasions partial movements might appear, for instance, 'arising' movements of the first stimulus, and 'disappearing' movements of the second, either singly or successively. Great controversy has arisen as to the relations of the period of exposure of the two stimuli, the time interval, the spatia distance between them, and their intensity. Wertheimer, and later Korte (1919), claimed that these quantities must bear exact and unvarying relations to one another in order that optimal movement should appear. According to Korte, who drew up three laws relating to distance, intensity, and time interval, optimal distance varies directly with intensity, optimal intensity varies inversely with time interval, and optimal time interval varies directly with distance. If the time interval is increased until succession results, optimal movement can be restored by decreasing the intensity or increasing the distance, and so on. Cermak (1922) pointed out that these relations hold only within certain limits of time and distance. And Neuhaus (1930) found that the relationships were considerably less simple than indicated by Korte. Thus if exposure time was constant, increase of distance required an increase of temporal interval between stimuli, for the appearance of movement, which usually came more easily the smaller the distance. With distance constant, a short exposure time required a long temporal interval, and vice versa, although the two were not inversely proportional. With certain constant values of exposure time and distance, the temporal interval was the decisive factor; but over a certain range of distance and exposure time, it had little effect on the appearance of movement. Variation of the exposure time of the second stimulus had little effect, but variation of the exposure time of the first stimulus had the same effect as if both were varied equally. Movement was readily obtained with temporal overlap, but only if the exposure time was greater than a certain minimal value. Variation of the physical intensity of illumination necessitated no change in other variables; within a wide range movement was obtained just as well with lights of different colours and intensities. Higginson (1926a), Van der Waals and Roelofs (1930), and McConnell (1927) all found that the phenomenon could be obtained with considerable variation in the relationships of time, distance, and intensity. And Ehrenstein (1939) considered that the essential condition was that the stimulation of one part of the cortex should be abruptly declining at the same moment that the stimulation of the other part was abruptly increasing.

Wertheimer was particularly concerned to stress the importance of the exact time interval and the exact spatial distance between stimuli, since these were necessary to his theory explaining the perception of movement in terms of cortical conduction. He considered that when two spatially separated retinal points are stimulated, excitatory processes are set up in the corresponding cortical points; and that these processes radiate out over the cortex from the points excited. There is a mutual attraction between the cortical excitatory processes which is demonstrated by the fact that the distance between two lines producing optimal apparent movement appears less than the distance between the same two lines when continuously exposed (Scholz, 1924). If now the process from the point excited first reaches the point excited second before the latter begins to radiate, we observe succession. If the two processes of radiation meet half-way between the two points, we observe simultaneity. But if the process from the first meets that from the second about three-quarters of the way across, then we observe movement from the first to the second. Thus the movement perception is dependent upon the temporal interval, the spatial distance between the points, and the intensity of stimulation—for if the latter is not sufficient the excitation will be insufficient to send out radiations from one point to the other. It is clear that this theory agrees with Korte's Laws. If the distance is long, the intensity must be sufficient to produce radiations powerful enough to travel that distance, and a time interval long enough for the process to occur. If the time interval is long, the distance must also be long, or the radiations will meet each other too soon; and if the intensity is great, the time interval must be short and the process speeded up, or else the distance must be long, or again the radiations will meet each other too soon.

It is also an essential part of the theory of Wertheimer that it should explain equally well the perception of real movement. The only difference would be that in the case of real movement the discrete retinal points stimulated would lie much nearer together. It follows that apparent and real movement should be phenomenally similar and should obey the same laws under parallel conditions of stimulation; though it is to be expected that apparent movement would be weaker and more uncertain, for since the stimulated points are much further apart, the forces between them would be weaker and less effective in producing the phenomenon. On the whole, it seems that optimal movement, pure phi phenomenon, is essentially similar in appearance to real movement under rather specialized conditions such that the movement is clearer and more striking than the object moving. Thus Dimmick and Scahill (1925) found that real and apparent movement appeared equally moving, although the real movement was often reported to be slower and smoother, the apparent movement rapid and jerky. (The distance and duration of the two movements was objectively the same.) Van der Waals and Roelofs (1930) presented both real and apparent movement tachistoscopically, and concluded that the phenomena were fully identical. For every real movement factors were present which in suitable conditions could produce apparent movement, and in a real movement phase in which no movement was visible the factors for production of apparent movement were also lacking. Again, in Brown's experiments on real movement (1931c), as the velocity of the moving square was increased, a stage was reached at which the real movement of the square upwards alternated with an apparent downward movement (to the position of the next square to appear). This apparent movement seemed to the observers to be as real and striking as the real movement upwards. Moreover, the threshold of ✓ appearance of the apparent movement was affected by changes in the structure of the field in exactly the same way as was the threshold for the perception of real movement.

More recent work by Brown and Voth (1937) has shown the similarity between real and apparent movement with other configurations of stimuli. If four points of light arranged in a circle are exposed successively at high speed, a circular movement will be seen along a track lying just within the circle which passes through the actual points. They observed a similar 'shrinkage' occurring with a light stimulus made to move at high speed around a circular track—that is to say, the perceived path of the light lay within its actual path. These phenomena Brown and Voth attributed to the action of centripetal 'cohesive field forces' in the cortex which drew the path of the light, whether really or apparently moving, inwards towards the centre of the circle. Similar forces are said to be demonstrated by the tendency of two visual, auditory, or tactile stimuli to appear too near together, when presented in fairly close succession to one another, before apparent movement begins. But according to Christian and Weizäcker (1943), the phenomenal movements of a bright point of light moving at uniform speed round a circle in a dark room differ considerably at different speeds. The circle of movement appears sometimes smaller, sometimes larger; or it may appear to rise and fall in space. Thus the effects of the 'cohesive field forces' apparently vary and do not exert a consistent effect.

Another experiment which might be said to demonstrate the effect of 'field forces' upon the apparent movement phenomenon is that of Weiskrantz (1950) on Köhler's 'figural after-effect'. In this experiment the observers looked steadily for a period of two minutes at two dark vertical bars at a horizontal distance of about 7 inches from each other. After that, apparent movement between two points lying just within the positions previously occupied by the bars appeared shortened by comparison with movement before fixation. But movement between two points lying just outside the positions previously occupied by the bars appeared lengthened. As in the experiments of Köhler and Wallach (1944), the limits of the pattern of movement receded from the contours of the pattern of satiation, as if the latter were exerting a repelling force upon the former.

Further evidence of the relationship of cortical factors to perception of both real and apparent movement is given by the work of Bender and Teuber (1946b) on patients with injuries of the occipital cortex. Vision of a moving object was sometimes replaced by the appearance of a succession of stationary images, thus as it were reversing the phi phenomenon. Or the path of movement might appear curved instead of straight, deflected perhaps by the altered excitability of the impaired regions, just as stationary figures tended to appear distorted (see p. 68). And in order to produce the phi phenomenon, alternation of stimuli had to be more rapid than was necessary for normal observers (that is, the temporal interval reduced). Werner and Thuma (1942) also found that brain-injured children could not see apparent movement with simple line stimuli; whereas equally retarded children without brain injuries were able to do so. The former also were less ready in perceiving rapid real movement.

But a great deal of work has been carried out to controvert the theory that the phi phenomenon depends entirely upon exact physical conditions determined in the cerebral cortex. In the first place, numerous experimenters claim that the phenomenon can appear under extremely diverse and unregulated external conditions. Piéron (1933) showed that if two points, one 2 degrees to the right of the fixation point of the left eye, the other 2 degrees to the left of the fixation point of the right eye, were stimulated successively then a clear impression of apparent movement was obtained. Smith (1948) also showed that if the nasal parts of the two retinae were stimulated alternately by bright points of light, most observers perceived pure 'phi'. From an analysis of the neural tracts stimulated, he concluded that no neural interaction could occur between the two stimulations. Shipley, Kenney and King (1945) presented alternating dots, both to one eye, or both to both eyes, or one to one eye and one to the other. Each of these three arrangements was compared simultaneously with each of the others. On the whole, binocular perception gave a better impression of movement than did either monocular or inter-ocular presentation; but the two latter were very similar to one another. Gengerelli (1948), however, used an arrangement of stimulus points such that if apparent movement was perceived in one direction, excitation of both hemispheres was involved; if in another direction, excitation of one hemisphere only. The latter type of percept was the more common, though frequent instances of the former also occurred. Thus clearly there can be integration of excitations from opposite hemispheres, though it may take place less readily than integration of excitations of the same hemisphere.

These results make it difficult to understand the nature of any physical basis in the cortex for the apparent movement phenomenon. Again, Humphrey and Springbett (1946) found that after-sensations, negative and positive, could be obtained of the stationary stimuli used for producing the phi phenomenon; but there was no after-effect of the apparent movement over the intervening space.

Moreover, the appearance of the phenomenon seems to be governed by a number of psychological conditions relating to previous experience, 'set', attitude, etc. One of the first to work on these conditions was Da Silva (1929), who presented real and apparent movement stimuli tachistoscopically, under comparable conditions of stimulation. He found that his observers did not readily perceive apparent movement; and that when they did, they confused it with real movement only when illumination was dim, and within certain narrow limits of speed and spatial interval. In general these conditions were such that the observer perceived 'movingness', but not the 'vehicle of movement'—either because it did not exist, as in apparent movement, or because it was too dim or rapidly moving to be seen, in real movement. Da Silva (1929) postulated the following theory: When there is a short pause between the presentation of two stimuli, and when the stimuli are near together, there is no time for them to produce processes which are separately and severally clear in consciousness. If the second member begins to 'clear up' in consciousness before the first has finished 'clearing up', the second becomes tied to the first in a unique spatio-temporal structure or Gestalt which, given a favourable attitude on the part of the observer, is translated into consciousness as 'movingness'. This structure Da Silva considered to be of an enduring kind comparable to one of Head's schemata. It represents 'movingness', and is a unique combination of extensity and protensity. If, however, the spatio-temporal interval is too large, the spatio-temporal structure will have time to 'clear up', its incompleteness will become evident, and there will be no movement interpretation. Again, if the 'vehicle of movement' is sufficiently clear in consciousness, the schema involved will possess other aspects connected with the qualities of the object; and the experience will be phenomenally different from that produced by apparent movement or rapid real movement. Indeed, as Bartley points out (1941), optimal apparent movement occurs over ranges of time and distance such that an object really moving at that speed (over that distance in that time) would lack sharp contours; thus the 'vehicle of movement' would not be clearly defined.

The conclusions of Mibai (1931) were rather similar to those of Da Silva. He considered that the flashing out and fading off of the two successive stimuli is the basis of the movement impression; though these impressions are actually stationary, they give the impression of movement when combined with the attribution of a movement 'meaning'. The movingness is a flashing sensation interpreted as motion by virtue of the circumstances connected with it. Linke (1913) has suggested that the observer must be convinced of the identity of the two stimuli—that is to say, that there is one stimulus moving in space, not two different stimuli exposed successively. This view is supported by Lehmann (1939), who stated that there is a tendency to organize the two percepts into a single unified event; this compulsion to identify the two stimuli produces closure. We must then explain why and in what circumstances this compulsion exists.

Favourable attitude, as constituted by deliberate instructions, unconsciously inculcated 'set', or previous experience, seems to be the operative factor. Higginson (1926a) stressed the importance of the 'set' of the observer—some 'highly habituated perceptive attitude'—in relating one member of the stimulus pair to the other. Da Silva (1929) found that a favourable attitude on the part of the observer was important. Neuhaus (1930) concluded that his laws held only for trained observers; under similar conditions untrained observers often saw simultaneity or succession. The 'set' or attitude produced by experimental instructions was also a very important determining factor. Kelly (1935) again found that when the simple apparent movement phenomenon was demonstrated to 400 students who had never seen the phenomenon before, about half reported seeing movement; but when told what to look for, more than 90 per cent saw it. Again, with ambiguous direction of movement, 95 per cent of a naïve group saw movement of the first of two alternative types when this had been suggested to them; but they were able to see the other alternative later.

This brings us to the consideration of a further determinant of the appearance and nature of the apparent movement phenomenon: namely, the form qualities of the stimulus objects. Hitherto we have discussed the appearance of the phenomenon when in general the stimuli were simple points or lines. But as these become more complex, different phenomena appear. Mere increase in complexity of form may facilitate the appearance of movement provided that this is congruent with the changes in shape or position of this form, and especially if the complex forms resemble simple moving objects. This is seen in the stroboscopic movement of the cinema;[1] and in simpler form in Da Silva's figure of the man raising and lowering his arm (1926). Again, in the so-called β movement of Kenkel (1919), which is really a special case of the phi phenomenon, movement appears when there is a difference of size between the two stimuli. An apparent difference of size may produce the same result, as in the α movement appearing when the two components of the Müller-Lyer illusion are exposed successively in the same position. Benussi (1914a) found that the appearance of the phenomenon depended on the observer assuming a synthetic rather than an analytic attitude. A similar phenomenon was demonstrated by Duncker (1929) with apparent difference of spatial position. If the two stimuli consist each of a dot surrounded by a rectangle, and the dots are presented in the same spatial position successively, but the rectangles in different spatial positions, then the dot will appear to move but the rectangle to remain stationary. This result agrees with Duncker's observations on real movement. Again according to Kenkel (1919) if the two stimuli differed greatly in impressiveness, that is to say, in intensity or configurational qualities, as well as in magnitude, the more impressive figure tended to move towards the less impressive; the two united together and returned to the position of the more impressive. This he called δ movement.

Although the phenomenon of the γ movement is usually included along with the other apparent movement phenomena, it does not seem to come within quite the same category. When a single spatial form is exposed very rapidly, there is an appearance of movement from the centre outwards; and when the exposure ceases, there is apparent movement from without inwards towards the centre. This is not simply due to change in illumination with consequent change of retinal stimulation—that is to say, expansion occurring with brightening and contraction with darkening. For when a dark figure is exposed on a white ground, darkening spreads outwards at exposure; the direction of the movement remains the same (Harrower, 1930). Moreover Lindemann (1922) found that this movement was governed by the general tendency of configurations to become as 'good' as possible, that is to say, simpler and more stabilized. If a small aperture was shown in an otherwise closed figure, the movement tended to close the outline; but if a large piece of the outline was omitted, the remaining parts tended to fly apart. If the figure was taken to be an object or 'thing', movement was inhibited, in accordance with the tendency we have mentioned for 'things' to appear stable and unchanging. Irregular figures tended to appear deformed by γ movement, the deformation being such as to make the figure look as 'good' as possible. Figures which were 'good' in themselves, that is to say, simple and regular, rarely showed deformation, although they might appear completely disrupted. There was also a tendency for movement to occur horizontally rather than vertically, another example of the unequal stress exerted by the horizontal and vertical components of the spatial framework.

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[1] Oldfield (1948) points out that the 'movingness' of the cinema film seems to be unaffected by wide variations in intensity and distance apart of successive presentations; thus Korte's laws do not obtain in this complex situation.

We come now to a set of apparent movement phenomena which contrast the effects of form and spatial position. The experiments of Ternus (1926) and Schiller (1933) were intended to demonstrate that if the relative positions of simple stimuli, such as points of light, were varied, then the resulting appearance of movement obeyed laws analogous to those governing purely spatial configurations such as were described on pp. 57–64. Thus Ternus (1926) presented a configuration in which the first stimulus consisted of three dots (shown by black dots in Fig. 21 *a*), followed by a second set of three dots (shown by the circles in Fig. 21 *a*). The position of two of these dots was identical, in the two stimuli. But the whole configuration appeared to move bodily from left to right—that is, from the position of the three black dots in Fig. 21 *a* to the position of the three circles. And the observer was unaware of the fact that the positions of two of the dots were identical in the two stimuli. The same effect was obtained if the first stimulus consisted of a white, a light grey, and a medium grey dot, and the second stimulus consisted of a light grey, a medium grey, and a dark grey dot. Again the whole configuration appeared to move bodily from left to right, changing colour as it did so. In the configuration shown in Fig. 21 *b*, the three top points were seen to retain their position and identity in the two stimuli; but the one below them, which was also exposed twice, appeared as part of the right-hand limb of the first stimulus, and part of the left-hand limb of the second stimulus—that is to say, its identity was not recognized.

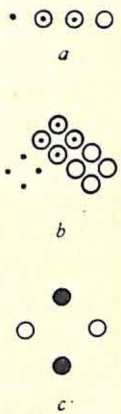

Fig. 21. Movement configurations produced by ambiguous stimulus constellations.

Schiller (1933) investigated the effects of the Wertheimer factors of proximity and similarity (see p. 69) on the apparent movement phenomenon. He exposed successively pairs of points arranged so that one pair was situated at either end of the arm of a cross, the other pair at either end of the other arm (see Fig. 21 *c*). Then if the angle between the arms was decreased, in general the factor of proximity came into play, and movement occurred across this angle. But if the dots on either side of the smaller angle were dissimilar in brightness or colour, and the dots on either side of the larger angle were similar, movement took place across the larger angle. Similarity showed itself to be stronger than proximity in this experiment, whereas in that of Ternus spatial position seemed to be more important than similarity.

Willey (1936) carried out experiments with a configuration similar to that of Schiller. He found that there were certain general tendencies at work, to see movement in a vertical rather than in a horizontal direction, clockwise rather than anti-clockwise. But the direction of movement was also governed by the previous experience of the observer in seeing movement; and by some unexplained perceptual bias which differed in different individuals. Voluntary intention to control the direction of movement had some effect, but mainly when it reinforced a preformed bias. The strength of the bias could be measured by varying the positions and distances apart of the lights, and finding how soon movement favoured by the position closer together overcame the movement favoured by the bias.

A similar set of phenomena has been demonstrated when the two stimulus lines are set at various angles to one another. If the first stimulus is a line erected perpendicularly to the second, a horizontal line, so that the configuration forms an inverted T shape, the first member may turn through 90 degrees either to the left or to the right; a fixation point to the left or right of the line will cause it to move in that direction (Van der Waals and Roeloffs, 1930). Or it may split at the top and move fan-wise in both directions (Da Silva, 1926), or split at the bottom and spread out (Van der Waals and Roeloffs). If a succession of pairs of lines is presented beginning with a pair forming an acute angle and continuing with gradually increasing angles, the movement will appear across the acute angle at first; but it may continue to take place in the same direction after the angle has become right-angled and even obtuse, up to 150 degrees (Wertheimer, 1912). If, however, the presentation series begins with this obtuse angle, movement will occur in the opposite direction, or one line may slide into the other. This example is often quoted to show the influence of attitude and expectation upon the nature of the movement; in the same way the splitting of the T-shaped figure is considered by Da Silva (1926) to depend to a great extent on attention and expectation.

✓We have seen that Schiller found similarity of parts to be operative in determining the direction of apparent movement. In some cases the attraction of similar parts will operate in such a manner as to produce three-dimensional movement. Thus Fernberger (1934) showed that if a pair of lines, one thick and the other thin, was succeeded by another pair of such lines with the thin one on the opposite side of the thick one, in most cases the thick line appeared stationary—presumably acting as a framework or point of reference—and the thin one appeared to jump over or under it. Again, if a triangular form such as those shown in Fig. 22 *a* was succeeded by a similar triangular form reversed with its apex pointing in the opposite direction, the triangular form appeared to rotate about its base into the new position (Steinig, 1929; Schiller, 1933; Higginson, 1926b). Orlansky carried out an extensive series of experiments on similar phenomena (1940). When dissimilar shapes such as those shown in Fig. 22 *b* were shown, three-dimensional swinging movements commonly occurred, but the range of time interval over which movement could be perceived was narrower than the range when the stimuli were exactly alike. In some cases, especially with greater dissimilarity of figures, fusion occurred; the outlines of the two figures became blurred and fused into a kind of composite, which then moved backwards and forwards between the positions of the two stimulus figures. Or in some cases the two figures appeared to whirl round one another in space. Finally, no movement could be observed when dissimilarity became too great. But the appearance of these phenomena, although partly governed by the shapes of the stimuli and the length of the time interval, also seemed to vary greatly between different individuals, and even with the same individual at different times.

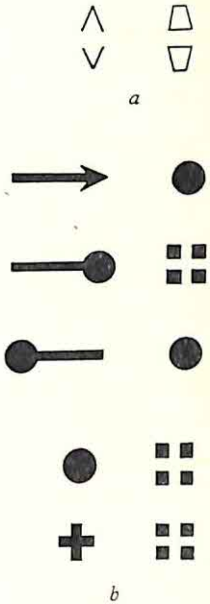

Fig. 22. Varying movement configurations.

It is clear then that an immense number of movement phenomena can be perceived, varying according to physical qualities such as distance, intensity, and time interval; configurational qualities and form relations; and subjective factors of meaning, 'set', and experience. There seems little doubt that the appearance of movement is a phenomenon *sui generis*, comparatively independent of the exact nature of the conditions under which it occurs. But it appears to occur whenever these conditions are such that the easiest and most acceptable interpretation of the configuration of sensory stimuli is in terms of the movement of a single body in either two or three dimensional space. We shall see again in the discussion of the phenomena of fluctuating attention in Chapter x that it often happens that there are many possible alternative ways of interpreting a given set of sensory stimuli. Nor is this at all surprising, in view of the immense modification that can take place between the exact form of sensory stimulation and the final perceptual experience. If the appearance of movement is the phenomenon which accords best with the schemata governing the perception of that type of situation, then movement will appear. But it seems clear also that such schemata are determined by subjective factors within the particular individual, as well as by objective physical factors and by physiological factors common to people in general. This may happen even in the case of real movement perception, as Metzger (1934) has shown. When shadows of moving objects were thrown on a screen, the varieties of movement which *could* have been perceived were very numerous. But in fact only a few of them were actually perceived. These were determined largely by the appearance of smooth and continuous movement—that is to say, the moving shadow appeared to continue its movement along the same path, even when it crossed another shadow, rather than change its direction. This phenomenon parallels that of 'good continuation', one of the Gestalt principles applicable to stationary figures. The movements perceived were also to some extent determined by individually different 'sets' and attitudes.

(3) FLICKER AND FUSION

It has been customary to consider the phenomena of flicker and fusion in conjunction with the phenomena of movement. Indeed, it may be postulated that flicker does have somewhat the same phenomenal nature as movement, although no change of position can be seen and no moving body. The γ movement described above forms an intermediate stage between the phi phenomenon and flicker. In the experiments of Brown (1931c) described on p. 164, as the speed of movement of the squares on the belt was increased, perception of real movement of the square upwards was accompanied by perception of apparent movement of the same square downwards to the position of the next square to come into view. With further increase of speed, a flickering band of light was seen, and finally a fused grey band. In the same way, as the speed of a rotating episcotister with alternating black and white sectors is increased, the sectors first appear to rotate, then to flicker, and finally to fuse. Thus, as regards physical qualities, there is a gradual transition between the conditions determining the phenomena.

Now the physical conditions in which flicker and fusion appear for alternating black and white fields (of equal size) have been quite clearly determined. The 'critical frequency', the rate of alternation at which flicker is replaced by fusion, increases with intensity of illumination and with area stimulated. It is also less in central than in peripheral vision; and in dark-adapted central vision than in light-adapted; and in light-adapted peripheral vision than in dark-adapted (Lythgoe and Tansley, 1929). There is little doubt that these phenomena are due to the properties of the retina and of conduction by the optic nerve. It does not therefore seem justifiable to relate them, as Cermak (1922) does, to the laws which Korte held to operate in apparent movement; since the experiments of Piéron (1933) and of Humphrey and Springbett (1946) demonstrated quite clearly that apparent movement phenomena were not retinal in origin.

But if instead of simple alternating black and white fields, configurational stimuli of some kind are used, then Gestalt factors may be observed to come into operation. Hartmann (1923) carried out experiments in which either there was an alternation between two different configurations; or a single configuration was alternately exposed and covered. It was then found that the fusion point depended not only on speed of alternation, intensity of illumination, etc., but also on the shape of the configurations, and on various subjective factors. Thus configurations which possessed the simplest and firmest structures tended to fuse most easily; circles tended to fuse more readily than triangles even when of the same area and surface intensity. Moreover, the same figure might fuse sooner when it appeared phenomenally simple (seen, for instance, as a square with a diagonal) than when it appeared phenomenally complex (seen, for instance, as two separate triangles). Different figures exposed successively were, of course, more difficult to fuse than were similar figures; so also were figures of like form and different colour. It was shown by the author (1934a) that the introduction of any black figure into a plain field illuminated by white flickering light reduced the critical frequency, but that the effect was relatively independent of the size and form of the figure. Consequently this effect was explained by assuming that it was an example of the 'figure-ground' phenomenon; that with a plain white field the flicker effect was 'figural', but if an actual figure was introduced into the field, this became the 'figure' and the flicker the 'ground'. Hartmann also found that flicker disappeared at a lower frequency in a field that was perceived as 'ground' than in one that was perceived as 'figure'. Thus we may conclude that retinal and nervous phenomena are here modified in certain perceptual settings, as was shown in the case of real and of apparent movement. They may be modified in the same way by cortical factors as are the perception of real and apparent movement. Thus Bender and Teuber (1946b) working with patients with occipital lesions found that the critical frequency of flicker was lowered in the affected areas; fusion was affected by the injured condition in the same way as were the perception of real and apparent movement. Werner and Thuma (1942) also found a lowering of the critical frequency in brain-injured children. However, they concluded from the fact that these children did perceive fusion, whereas they did not see apparent movement with simple line stimuli, that the flicker and fusion phenomena, though of central origin, could not be identified with the phi phenomenon in the manner indicated by the Gestalt psychologists.

CHAPTER IX

MICHOTTE'S STUDIES OF SOME INTRINSIC PHENOMENA OF EXPERIENCE

(1) MECHANICAL CAUSALITY AND 'INTENTIONALITY'

Of recent years certain particular types of movement phenomena have been studied by Michotte in a series of most interesting and ingenious experiments. The earliest of these were devoted to the phenomenal impressions obtained when one object is set in motion and comes into contact with a second object which then begins to move in turn. With suitable conditions of velocity and direction of movement of the two objects, an immediate impression of *causality* is obtained—that is to say, the movement of the second object appears to be *caused* by the impact of the first. This impression is as simple, direct, and fundamental as is the impression of movement in the phi phenomenon. It does not depend upon reasoning or on previous experience, or even, within certain limits, upon the nature of the moving objects. But it is constituted by a specific organized system of sensory impressions—that is to say, a particular configuration of position, direction, and speed of movement. This configuration is analogous, or rather complementary, to that constituting the phi phenomenon.

Michotte in his experiments (1946) did not use real objects, one of which actually set the other in motion. Arcs of circles and curves having various angular directions were marked on a disc which rotated behind the slot in a screen in such a way that a black square, A, was seen moving along the slot until it touched a red square, B, which then began moving in turn (see Fig. 23). (The results were confirmed by projecting moving squares from a projector on to a screen.) In one set of experiments, A remained motionless when it had touched B; in a second set, A continued to move along behind B and in contact with it. In the first set, A appeared to *launch*, *push*, or *propel* B (*'l'effet Lancement'*); in the second set, A appeared to *carry B along* with it (*'l'effet Entraînement'*). The phenomena were seen whenever the conditions of speed and direction of movement were such as would be expected if a real object either launched another, or carried another along with it.

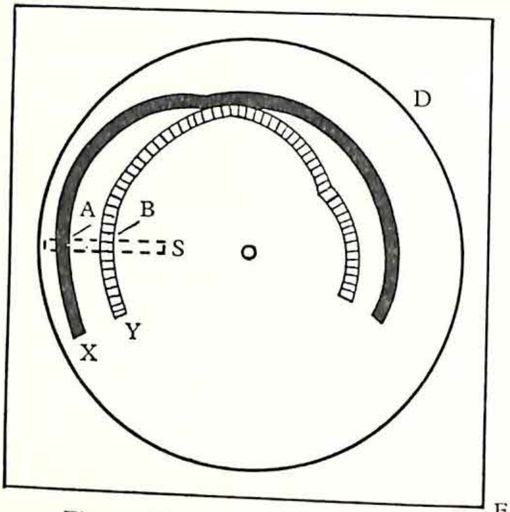

Fig. 23. The causality phenomenon.

The particular physical conditions for the appearance of the phenomena were found to be as follows:

(1) The *speeds* of A and B should not be too fast or too slow. If they are too slow, the movement of B will appear to be unconnected with that of A, and not to be caused by it. If too fast, one continuous movement of two fused objects will be seen. For A to appear to propel B, the speed of B must be either equal to or less than the speed of A. If the speed of B is greater than that of A, B will seem to be 'released' by A, or to be running away from it, but not to be propelled by it. If A and B after contact continue to move together at an increased speed, the impression resembles somewhat that of a cat springing on a mouse.

(2) There should be a very short *time interval*, of the order of 30–40σ, between the moment when A comes in contact with

B and when B begins to move. If this interval is too long, or if A and B move at very high speeds, A may appear to 'tunnel under' B and proceed in the same direction in one continuous movement, while B remains stationary.

(3) The *direction* of movement of B must not differ greatly from that of A, or else the movement of B will appear to be unconnected with that of A. For A to appear to propel B, it must either cease to move when it comes in contact with B, or continue to move in the same direction at a slower speed.

(4) The *distances* moved must not be too great, especially in the case of B. The shock of impact has a certain 'radius of action', and if B moves too far, it will go beyond this. The impression of causality may be destroyed because B will appear to possess its own power of movement, rather than to be pushed by A. The 'radius of action' increases, however, with increased speed of movement of A and B.

(5) The two objects must be *clearly visible*, that is to say, be viewed in central vision, in good light and not too far away, in order that they may be seen to retain their *separate identities*. Otherwise a continuous fused movement will appear, as in the phi phenomenon, where we saw that it was necessary for the two stimulus objects to assume a single identity. But the shape of the two objects does not matter; quite vaguely outlined patches of light will produce the phenomenon. In general, A should be fixated, since it is the causal agent, dominating the effect.

If the physical conditions necessary to produce the 'launching' or 'carrying along' effects do not obtain, then a variety of other types of phenomenon may appear, such as unconnected movements, fused continuous movement, 'running away', 'tunnelling under', and 'transportation'. In *transportation* (which Michotte demonstrated from the movements of two rectangular projected patches of light), the larger of the two objects, situated beneath the smaller, appears to move along; but the smaller, while seeming to be supported by the larger, and also to change position, does not appear to possess any movement of its own caused by the movement of the larger.

Michotte demonstrated further phenomena which he considered to be characteristic of the *autonomous* self-caused movement which occurs in man and animals. Such phenomena were obtained in the observation of the alternate contraction and expansion, together with simultaneous translatory movement, of a simple rectangle. The change of shape and the translatory movement were integrated together, producing the impression that the contraction and expansion of the object made it advance, like a caterpillar crawling or a tadpole swimming. Here then change of position was not perceived to be mechanically imparted by one object to another, but to be produced by the interior activity of the organism.

The essential characteristics of the phenomenon which we perceive as mechanical causality are then said to be demonstrated in the two effects, 'launching' and 'carrying along'. The important features of these are that A moves, and hands on its movement to B, which then changes its position in a related manner. There is thus a production or indeed a 'generation' of a new movement in B which is both different from the original movement of A, but yet is integrally related to it, in that the movement of B is an extension or evolution of the movement of A. These then are the essential characteristics of the phenomenon which we perceive as mechanical causality, and it is upon this immediate phenomenal impression that all our ideas of mechanical causality are based. And all the phenomena of mechanical causality in which no qualitative changes (of shape, colour, etc.) occur demonstrate either the 'launching' or the 'carrying along' effect. But just as in general the impression of movement is usually produced by a moving object (though not necessarily so, as for instance in the phi phenomenon), so also the impressions of 'launching' and 'carrying along' usually correspond to the activities of some real mechanical force. Nevertheless, it is an impression arising spontaneously, and not one which is produced by experience in perceiving the actions of mechanical forces. Experience merely serves to define more precisely the conditions in which mechanical causality is perceived.

Michotte is concerned to maintain this position in opposition to the theory of Hume on the one hand, which states that the impression of causality cannot be directly perceived, but is a deduction from the results of experience; and on the other hand to the theory of Maine de Biran that the impression of causality results from the internal experience of forcefulness or 'efficacy' which is felt whenever we voluntarily cause something to move. Hume's theory seems to be discounted by the observations of Michotte, and by those of Piaget which we shall now consider. But the theory of Maine de Biran seems to fit rather well some of the phenomena observed by Piaget in the development of children's ideas of and attitudes to causality (1937).

The child's earliest notions of causality appear to result from the movements which he himself causes in external objects, though at this stage there is little if any differentiation between himself, the producer of the event, and the external world in which the event occurs. At about the age of five to six months, he may achieve the realization of some degree of 'intentionality', for instance in causing his own limbs to move; this seems to correspond to Maine de Biran's internal experience of power, forcefulness, or 'efficacy'. And movements of external objects which happen to occur at the same moment as one of his own movement efforts seem to be regarded as 'intentioned' in the same way. Thus movements which were effective in causing certain desired ends might be repeated in order to produce events which had happened to occur at the same time as his own movements. Again, violent body movements would make his cot rattle; the child then tried to make his father go on rattling on a box by making the same body movements. Thus quite unrelated pairs of events might appear to the child to be causally related, whenever an event occurred in conjunction with some motor activity, particularly a causal activity originating in the human body.

But at about the age of eight to nine months the child seemed to begin to realize that to cause movements of objects he must have some kind of physical contact with them, though he was not at all certain what kind of contact. Nevertheless, he began to understand that he could not 'magic' them at a distance. He also began to realize that causality is involved in the actions of others, for instance by moving another person's hand in the attempt to make it perform a desired action. However, he did not conceive of others as independent originator of actions, un-acted upon by himself, until he reached the age of about a year. And at this age also he began to understand that causality can occur between external inanimate objects, for instance, by one object pushing another; and to recognize with fair accuracy the necessary spatial relations between them. But this recognition varied with the particular circumstances, and with the mental development of the child, as is shown by the following examples:

> À 1:0, Laurent est debout à côté d'un battant de fenêtre ouverte, contre lequel appuie le dossier d'une chaise. J'imprime alors au battant de fenêtre un mouvement en poussant légèrement du pied la chaise. Laurent, qui n'a pas remarqué le mouvement de mon pied, est surpris par la déplacement de la fenêtre, et cherche à le comprendre: il remet le battant de fenêtre contre le dossier de la chaise, puis donne une petit secousse à celle-ci pour s'assurer que c'est bien elle qui était cause du mouvement. Il n'est satisfait qu'après avoir reproduit exactement le phénomène (Piaget, 1937, p. 276).
>
> À 1:6, Jacqueline marche dans une chambre et vient à ébranler une chaise dont le dossier touche l'un des battants d'une fenêtre ouverte. La fenêtre en est un peu déplacée et Jacqueline remarque le mouvement ainsi imprimé indirectement: elle saisit alors la chaise des deux mains et l'ébranle, intentionnement cette fois, en regardant la fenêtre et les secousses ainsi produites. Après quoi, Jacqueline continue sa promenade dans la chambre, sans plus paraître s'occuper de la chaise. Mais, heurtant une autre chaise, à deux mètres de là, elle la saisit, l'ébranle comme précédemment, et regarde la fenêtre. Elle voit bien qu'un large espace vide sépare de cette fenêtre et qu'aucun contact intelligible n'existe entre celle-ci et la nouvelle chaise: néanmoins, et malgré l'échec de sa tentative, elle continue un bon moment à secouer la chaise en regardant la fenêtre (Piaget, 1937, p. 304).

But Michotte (1950a) would distinguish impressions of causality distinguished by 'feelings of efficacy' such as the above from those of true mechanical causality. In his most recent researches he has further developed his techniques to produce effects which may indeed give some impression of *purposiveness* or *intentionality*, as distinguished from pure *mechanical* causality in which appears no such 'purpose to cause something to be done'. An experimental arrangement can be used such as that employed to demonstrate the 'launching' and 'carrying along' effects. The square A moves towards the square B, but stops short of it, and at the same moment B jerks rapidly forwards. Or A moves towards B which also moves away; at a given moment B stops, and A springs rapidly backwards. In both these cases the impression may be gained that A 'purposes' to catch B; in the first case, B escapes, but in the second it turns on its pursuer and repels it. In another arrangement, two squares move towards a rectangle. When they are quite close, the leading square springs beyond the rectangle. The squares then close in on the rectangle, 'grip' it, and move backwards with it along the same path. Again the squares may appear to 'purpose' to catch the rectangle and carry it off.

It would therefore seem at first sight that it is possible to create artificially the appearance of a phenomenon essentially characteristic of the behaviour of living organisms—just as it is possible to create the appearance of *mechanical* causality. It could then be argued that the appearance of 'intentionality' is also based upon certain simple patterns of movement—when for instance certain successive events form a 'whole', and the earlier events tend to evolve in a direction which is influenced by the course of the later events. (Such a phenomenon also occurs in the musical cadence, where the succeeding chords seem impelled by the preceding chords to move towards a certain end.) The basis of the phenomenon in Michotte's experiments seems to be that an event begins to take place, but suddenly something interferes with it, and the intervention appears 'purposive'. A combination of three events shows the phenomenon most clearly—for instance, a movement, a change of some kind in this, and a different, terminal, movement.

But in one important respect Michotte's experimental findings on the phenomenon of 'intentionality' differ from those on the phenomenon of mechanical causality. The former phenomenon is much more labile than the latter. Observers may not receive the impression of 'intentionality' unless it has been suggested to them that it might appear. Or they may perceive 'intentionality', but differ greatly in their impression of *what* was intentioned. Furthermore, the physical stimulus conditions are less rigid with this phenomenon than with the phenomenon of mechanical causality. Michotte considers that the 'intentionality' phenomenon probably results from an 'interpretation' of the perceived movement pattern, rather than from a direct and immediate impression. This interpretation is not merely an intellectual rationalization, but is reached by a process of 'empathy', the perceived movement combination being rendered into the experience of purposiveness by empathic feeling. This process seems to come rather close to Maine de Biran's 'feelings of efficacy'.

An experiment carried out with rather more elaborate stimulus conditions by Heider and Simmel (1944) seems to give evidence of the readiness with which 'intentionality' may be perceived. A short film lasting three minutes was shown in which a large and a small black triangle (*T* and *t*) and a small black circle (*c*) moved about the screen, and in and out of a rectangle one side of which was opened and closed from time to time. Every observer except one spontaneously described these movements in terms of human activities and the intentions with which these activities were performed; for instance: '*T* hits *t* because it wants to hurt it'; '*T* chases *c* because it wants to catch it'; '*c* moves into the house (the rectangle) because it wants to hide'; '*t* opens the door of the house and *c* escapes from *T*'. There was considerable agreement between different observers, though variation in detail, as to the situation of conflict between T, which was large and aggressive, and the smaller *t* and *c*. Here again the impressions produced by the moving shapes seem to have been interpreted by empathy in terms of motive and purpose.[1]

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[1] More recently, Michotte (1950b) has described the use of similar emotional animistic terms by observers in his causality experiments. Approach between the two squares was associated with positive, 'integrative', emotional feeling; and separation between the squares with negative or 'segregative' feelings. Rapid motion gave the impression of violence; slow motion, of gentleness; and sudden and repeated variation of speed and direction, of agitation.

(2) 'REALITY' AND VOLUME

In the other fundamental phenomena of experience studied by Michotte and his collaborators, observations of movement processes have played a part, but these have been combined with other types of experimental data. The main problem which has been studied is the nature of our impressions of the '*reality*' of the objects and events which we perceive. In the past this problem has been approached largely by the method of *a priori* reasoning; Michotte has attempted to explore it by an experimental investigation of the conditions in which we perceive things as 'real'.

Again he is concerned to controvert the theories of Hume, of Dilthey and of Helmholtz that we learn what 'reality' is by reasoning from our experience of dealing with 'real' solid objects. These theories have received some corroboration in recent years from the work of Piaget, to which we referred in Chapter II, on the gradual development of the understanding of 'reality' in children by means of the motor sensations and reactions experienced in manipulating objects. Michotte (1950a) considers, however, that, although we may acquire knowledge about the nature of 'reality' through learning from experience, yet we nevertheless have a primary, fundamental, direct, and unanalysable impression of 'reality'. This impression that a thing is 'real' can be differentiated from our knowledge or belief in its 'reality'. For instance, in the cinema we receive the impression that the movements of objects on the screen are 'real' movements, although we know that in fact they are merely a succession of images in different spatial positions. Again, in ordinary life we spontaneously distinguish between an object which is 'real' and a picture of that object which is not. Michotte has attempted to investigate what are the conditions leading to this direct impression of 'reality'.

One of the factors which has been suggested as constituting an essential characteristic in the impression of 'reality' is the perception of *three-dimensionality* or *volume*. We have already, however, noted that in certain cases such as with the outline drawing of a cube a visually perceived figure may appear as three-dimensional without giving the impression of 'reality' (see p. 92). Michotte (1948) found that the three-dimensional depth of such an outline drawing could be estimated with the same degree of accuracy as that of a real wire model of a cube. The outline drawing could be seen to possess three-dimensionality, yet no one supposed that it could be touched and handled in the same way as could the wire model.

It is Michotte's contention that the lack of 'reality' in the appearance of the outline drawing is due to the fact that the lines of the drawing actually *belong* to the plane of the paper. In the same way, a mirror image is distinguished from 'reality' because it can be seen to 'belong' to the plane of the mirror. If, however, the lines of a figure can be to some extent detached from the plane of the paper, then it will gain in both volume and in 'reality'. If the drawing shown in Fig. 24 is viewed monocularly from one side, with the eye almost in the plane of the paper, it may appear as if it 'really' bulged out of the paper.[1] Or if a flat wire model is shaped to appear like the outline drawing of a cube (see Fig. 18, p. 92) and is looked at monocularly from a distance, it looks as 'real' as the wire cube; in fact the two are indistinguishable. Thus whenever the factors of three-dimensional organization conflict with those which tend to confine the object to a two-dimensional plane, the impression of 'reality' is lost. But if the latter factors are minimized, there is a gain in the impression of

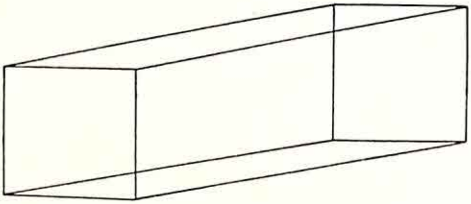

Fig. 24. The appearance of volume.

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[1] This phenomenon was later investigated in some detail by Phemister (1951). One factor of importance in producing the impression of 'reality' seemed to be that the figure when seen obliquely should resemble phenomenally the represented object, but should not be in geometrically correct perspective. Thus the effect of constancy, which appears quite clearly in the oblique view, should be enhanced by the manner in which the figure is drawn. But any phenomenal qualities which stress the 'belongingness' of the figure to the plane of the paper minimize the effect of 'reality'.

'reality'. Or the same effect may be produced by strengthening the factors of three-dimensional organization. For instance, in a cinematographic film the three-dimensional apparent movement of the photographic images seems to liberate them from the plane of the screen, and hence to produce the appearance of 'real' solid objects in motion. If the film is suddenly stopped, the images lose their appearance of 'reality' and are seen as perspective images located in the plane of the screen. Or if the shadow of a wire cube is thrown on a screen, and the cube rotated, the moving shadow may appear as 'real' as the cube itself. Again the movement strengthens the factors of three-dimensional organization.

Thus it seems that a number of configurational factors, when suitably organized within the perceptual field, will produce this direct and immediate impression of 'reality', just as other configurational factors can produce the immediate impression of movement or of mechanical causality. In everyday life, of course, these factors usually appertain to what we *know* to be 'real' solid objects. But the work of Michotte appears to show that the configurational factors are responsible for producing that primal impression about which are organized our acquired knowledge and beliefs as to what is 'real'.

(3) 'SUBSTANTIALITY' AND 'PERMANENCE'

The 'things' which we perceive in our environment have not only 'reality', but also 'substantiality'—that is to say, they consist of solid substance. These two qualities must be distinguished. For a number of events such as sounds, movements, etc., even empty space, have 'reality' but no 'substantiality'. But solid objects, segregated and localized in three-dimensional space, have 'substantiality'. One criterion of 'substantiality', then, is three-dimensionality; another is 'permanence'. But Michotte has found it possible to demonstrate conditions in which the immediate impression of *permanence* can be isolated from the other aspects of 'substantiality'.

In the first place, he has shown that phenomena can undergo *change* in certain ways and yet retain their appearance of permanence—that is to say, the impression that they existed before the change, are continuing to exist, and will retain their essential identity after the change. If a patch of light is projected on a screen, and is instantaneously replaced by another patch of light in exactly the same position but different in some characteristic, such as size or colour, from the first, the impression may be obtained in certain circumstances of a single object retaining a permanent identity. But it will seem as if a new object has been substituted for the original one if the changes are too great or too numerous—if, for instance, both colour and size are changed simultaneously (Michotte, 1950b). Thus normally the identity of an object resides in the structural configuration of properties such as shape, colour, size, etc. Certain of these properties may be altered without loss of the object's permanent identity, provided that a certain configuration of properties constituting the *cachet specifique*—the 'essential quality'—of the object is retained.

In a second type of situation, objects may seem to retain their permanence while suddenly appearing or disappearing. Conversely, there may be the impression that something completely new has been created, as in the case of the appearance of bubbles, or of the flame from a match. An example of the *appearance* and *disappearance* with retention of identity is given by the *screening* and *unscreening* effects. These were studied in detail by Sampaio (1943). He projected upon a screen: (*a*) A point of light which moved horizontally for a certain distance and then disappeared; (*b*) A rectangular patch of light A which moved towards a stationary rectangular patch B; when A came in contact with B, the line of demarcation between them remained stationary, while the further edge of A moved inwards until finally A disappeared; (*c*) A single rectangular patch of light one vertical edge of which remained stationary while the other moved towards it until the light disappeared; this effect might or might not be preceded by a horizontal translatory movement of the patch towards the point of disappearance. In all these cases, the majority of observers saw the moving objects not as merely disappearing, or shrinking up to nothing, but as *gliding* behind some screening object which hid them from view. In (*a*) and (*c*) the screening object was created by the observer from the plain and featureless background. If the patch of light reappeared again at a certain distance and continued to move, then it looked as if it had *tunnelled under* the intervening space. The characteristic feature of these screening and unscreening effects was that the moving object lost its boundary line and seemed to have no limit, while the line of demarcation appeared then to belong to B or to the imaginary screening object in (*c*).

In certain conditions these effects were destroyed. If the moving patch of light in (*c*) was structured and not uniform throughout, this structure could be seen to remain motionless in space, which was incompatible with the gliding of the object behind the screen. However, it appeared in some cases that a screen was being gradually moved in front of a stationary object; or that the object shrank, or folded up like a fan. If the patch of light had two rounded ends like a sausage, there was rarely any screening effect, and the patch generally seemed to shrink up, because the curved ends continued to appear to belong to the object itself.

The obverse effect of unscreening could easily be obtained by simply reversing the conditions. But, as noted on p. 44, it was destroyed if the emerging figure was too greatly elongated. In the same way, the screening effect did not appear if the disappearing rectangle of light was too long. Moreover, it was essential that the movement should lie within a certain range of speed, neither too fast nor too slow. If the speed of expansion or contraction was greatly increased, other phenomenal effects appeared.

Before proceeding to describe these, we must first consider the case of retention of permanent identity with sudden appearance which occurs when we turn on the light in a dark room (Michotte, 1950b). The illuminated objects in the room will seem to possess permanence. But the light which spreads in a γ movement to all parts of the room will appear to be created at that instant, and to have no previous existence. Or if in a dark room a bright image is suddenly projected on to a screen, it will also appear as a new creation, without previous existence or permanence. But it is not our knowledge of the reality of the objects in the room which gives them their impression of permanence. For consider the following experiment:[1] A square of grey paper was fixated, and was suddenly replaced by another grey square in the middle of which was situated a small real object such as a screw. No change of any kind was apparent in the grey background. But the object was seen to arise out of the background as if a totally new existence were being created, often with a γ movement as it appeared. There was none of the impression of unscreening a previously existent object. If, however, the grey square with the object in the middle of it was made suddenly to appear in an otherwise totally dark room, there was no creative effect. The object seemed to have a permanent identity and continuity, and to be suddenly exposed as in the case of the objects in the suddenly illuminated room; and there was no γ movement.

But it was also possible by gradually modifying the conditions to demonstrate the existence of certain transitional stages between the appearance of a previously existing object and the sudden creation of a new one. An investigation of these transitional stages was carried out by Knops (1947). He projected upon a screen patches of light which either appeared instantaneously, giving the impression of sudden creation; or gradually increased in size, from a pre-exposed patch, until they reached the same size as the instantaneously exposed patch. The speed of growth and the sizes and shapes of the patches of light were varied.

When the growth of the patch of light was very rapid, γ movement appeared, and there was an impression as of an explosion, or of the sudden opening of an aperture. These were true creative phenomena in which the whole mass grew out from its original point of appearance. They occurred only with very small and punctate objects; or with larger patches at very high speed. When the speed was somewhat reduced, a 'spreading out' phenomenon was seen, in which the patch of light appeared to 'unfold' itself like a fan, or to expand like a telescope. Here it seems that there was partial creation and partial permanence; new portions of matter appeared between the preexistent masses. The phenomenal identity of the whole was retained although part of it was new.

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[1] This experiment can be carried out by the use of a rapidly rotating reflector, or of an apparatus such as the Dodge tachistoscope.

With a further reduction in speed of growth of the patch of light, the next appearances were those of 'dilatation', like that of an elastic object (characteristic of fairly broad patches), and 'elongation', like that of the mercury of a thermometer (characteristic of narrow lines of light). Here the impression was that matter already in existence grew and increased in size. Finally, the unscreening effect appeared; or, if the patch of light grew on one side only, the 'protrusion' of one object from behind another.

This phenomenon of *protrusion* was investigated in some detail, with another presentation, of a white rectangle B which was gradually extended outwards from the edge of a red rectangle A. This condition was of course the same as that in Sampaio's condition (*b*). If B was narrower than A, moved comparatively slowly, and was not unduly extended, an impression of 'protrusion' was obtained like that of the catch of a door. On the other hand, if B was extended to a considerable extent, protrusion no longer appeared, but B seemed to elongate and dilate of itself. If B was made very narrow, it appeared to 'grow' rather than to protrude from behind A. Again, if A was made narrower than B, protrusion was not perceived, but it might appear that A moved and uncovered a wide band B. Whenever there was an impression of protrusion, the movement was characterized as appertaining to the right-hand contour of B, while the boundary line appeared to belong to A and not to B. Thus again the impression of permanence of an object which had been covered over by another object was associated with the fact that the contours of the total configuration were perceived to appertain to the covering figure and not to the covered.

Neither do the *temporal* limits of the phenomenon, according to the most recent statements of Michotte (1950a and b) belong to the covered and protruding figure. The temporal existence of the figure necessarily appears unlimited, because it constitutes a part of the total stream of experience. Any event which possesses its own clear and characteristic time limits will appear as a sudden creation or as the gradual evolution of something new without previous existence. In the protrusion and unscreening effects there is no appearance of internal evolution in the protruding or unscreened objects. The temporal limitation of the phenomenon belongs only to the gliding movement of the object, marking the beginning of the movement, but not in any way affecting the period of existence of the object itself.

Again in the case of the room suddenly illuminated, this illumination has a temporal limitation, a beginning and end constituted by switching the light on and off. But the objects have no temporal limitation; they are located within the general framework of psychological time. In the first case of permanence described, when the individual properties of the object were changed, there was, it is true, a partial evolution of certain of these properties which possessed an earlier limit in time. But the 'essential quality' of the object did appear to pre-exist, and to continue to exist, without temporal limits, after the change.[1]

Hence essentially in all these types of phenomenon of permanence, there was, of course, an existence *in* time, but this existence was not *limited* in time.

In summing up this and the previous chapter, we see that there is a whole group of related phenomena which derive from certain characteristic combinations of spatial and temporal configuration. For each phenomenon, the physical concomitants of the configuration may vary quite considerably. But as between the different phenomena, the physical conditions are not dissimilar; yet the phenomena are quite sharply defined and delimited from one another. Experiment has not demonstrated the exact nature of the requisite physical conditions and their inter-relationships; or even determined if the physical conditions need to be at all exact within a wide range. We might be tempted to think that we perceive these configurations as movement, causality, permanence, etc., in the circumstances in which we should expect to perceive them as such; or at least that our perceptions are the result of previous similar experiences in which other data, for instance, from tactile and kinaesthetic impressions, suggested the existence of movement, etc. But the stimuli in Michotte's experiments are so unlike those which normally exhibit mechanical causality, 'intentionality', permanence, etc., and yet the impressions of these phenomena are so spontaneous, immediate, and convincing, that it is difficult to see how they could result from previous similar experiences. It is perhaps possible that in our endeavours to account for and react appropriately to rapid changes in our environment, we canalize these percepts along the lines of the schemata most appropriate to the occasion. It may be that these schemata have an innate basis. But they have the function of categorizing and differentiating the percepts much more sharply from each other than their physical differences would suggest as possible. These schematized percepts are formed rapidly and cursorily to meet the needs of everyday life, rather than carefully and analytically. When we do attempt to assess by experiment the basic physical conditions, we interfere with the normal operation of the schemata, and are therefore unable to analyse the constituents of the percepts or of their organization with any certainty.

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[1] In fact, the phenomenon parallels the constancy phenomena. There is a differentiation of the temporal field into the 'figure' which maintains temporal permanence or constancy, and the 'ground', the illumination, which appears in time, changes and disappears.

CHAPTER X

THE INFLUENCE OF INTERNAL AND INDIVIDUAL FACTORS UPON PERCEPTION

(I) LEVELS OF ATTENTION

We have now discussed in detail the main categories into which the phenomena of visual perception may be grouped. We have investigated the principles governing the perception of shapes and of objects; the spatial setting within which they are arranged, and their relationship to which plays so large a part in their perceived qualities; and the phenomena of movement which seem to exist to some extent independently of the objects moving. This discussion has related in the main to the phenomenal qualities of the external world. Although, as we have shown, these qualities are to a great extent determined by certain schemata common to the minds of most observers, yet it is equally clear that they are in fact attributed by the observer to the external world and the objects within it. We must now turn to consider those attributes of the perceptual experience which the observer always regards as being a function of his own mind.

We shall deal first with the attribute of 'attention'. Whatever the controversy as to the exact nature of attention, it cannot be denied that every observer thinks of his 'attention' as existing in himself. It may be stimulated by certain external conditions and events, but it is never projected upon them. Thus one speaks of being 'forced to attend' to a particular stimulus, but not of a stimulus being 'attentional'. In attending, the observer considers that from time to time the clearness, accuracy, and detail with which he perceives any particular object or set of objects vary irrespectively of the nature of these objects. This variation may occur spontaneously, or be brought about deliberately, but it is felt to occur within the observer's own consciousness, and is not attributed to the objects as a function of their intrinsic nature.

This is not to deny that variations in the degree of clarity of perception may be closely related to, or even determined by, qualities of the objects in the external world. Dallenbach (1920), for instance, preferred to use the word 'clearness' for what had often been termed 'attention'. He then distinguished, and attempted to induce his observers in his experiments to distinguish, between 'attributive' and 'cognitive' clearness. 'Attributive' clearness was related to differences in the clarity of perception which were conditioned by sensory qualities of the stimulus, its size, brightness, etc. 'Cognitive' clearness was determined by the ideas and meanings of the stimulus, the attitude of the observer, and so on. But these types of clearness were closely related, and difficult to distinguish in practice. Indeed, it is obvious that those particular sensory qualities which are responsible for 'attributive' clearness are at least to some extent determined by the observer. For instance, certain particularly striking colours such as scarlet may be said to be responsible for both 'attributive' and 'cognitive' clearness.

Much study has been expended by Wundt and by Titchener and the Cornell school upon the different 'levels' or grades of clearness of which the observer can be aware while perceiving. The highest of these, 'the range of our clear experience', was called 'attention' by Titchener (1908, 1917). But it seemed to have two levels of clearness corresponding to what Wundt called 'apperception' and 'perception' (1896). The former was fully cognized and apprehended, while the latter applied to that part of the external field of which the observer was generally aware but of which he had no detailed knowledge.

Among later workers, Dallenbach (1920) was mainly concerned to distinguish between 'attributive' and 'cognitive' clearness, and to determine the number of levels of clearness in awareness. His usual experimental method was to expose groups of figures tachistoscopically, and require his observers to report on the degrees or levels of 'attributive' and 'cognitive' clearness with which they perceived them. In general, high degrees of 'cognitive' clearness were experienced in conjunction with high degrees of 'attributive' clearness, but the former were distinctly more numberous. Oberly (1924) carried out experiments similar to those of Dallenbach, in which he required his observers to report the number of black dots exposed tachistoscopically on a white ground, and also the degree of certainty of their report. He was able to distinguish three different types of perceptual process: (1) An immediate process in which all the sensory elements were at one equally high level of clearness; (2) an immediate process in which the elements were grouped with different degrees of clearness; (3) a mediate process, involving reimaging the stimulus field and counting its elements. The first of these processes, which existed at a simple, direct sensory level, he termed 'attention'. The second and third clearly involved different degrees of cognition; he termed (1) and (2) together 'cognition', and (1), (2), and (3), 'apprehension'.

It is clear that the first of these processes must take place at the highest level of cognitive and attributive clearness. The second involves the grading of the perceptual field into various levels of clearness; while the third seems to provide for the lack of attributive clearness of parts of the field by subsequent, voluntary enhancement of their cognitive clearness. The chief controversy over these results lies, however, in the nature of 'attention'—whether it exists as a process or as a level, and whether it exhibits one high degree of clearness, or a number of degrees which indicate differences in the objective 'perceptibility' or the subjective 'cognizability' of the parts of the field. For the details of this controversy, the reader is referred to successive papers by Fernberger (1921), Oberly (1924), Dallenbach (1927), and Cooper (1928). Here it suffices to say that to use 'attention' merely as a name for the highest level of cognitive awareness seems to make it a purely redundant term which might well be suppressed, hence engendering an access of clarity to psychological thought. We shall prefer to consider attention as an active process of attending, of the direction of awareness, either spontaneously or voluntarily, towards different parts of the perceptual field.

(2) FLUCTUATION OF ATTENTION

It must be recognized that certain qualities existing in particular parts of the perceptual field cause the observer spontaneously to direct his awareness upon them. Of these, the most important is intensity. But even this must be qualified; it is the unusually or unexpectedly intense to which awareness is immediately directed, especially if that intensity is likely to be harmful or dangerous. The most intense of all visual stimuli, the sun, is by no means always the centre of awareness, unless it suddenly appears or causes discomfort. That is to say, it is the significance of the intense stimulus to the observer which causes him to attend to it, rather than its mere intensity. And since the unusually or unexpectedly intense is always potentially dangerous, and the observer must therefore react to it immediately, it is always liable to stimulate attention.

At the other end of the scale come those stimuli the intensity of which is so feeble that the observer has great difficulty in becoming or remaining aware of them. There is in general a rhythmical fluctuation of awareness of liminal stimuli. There has been considerable controversy as to the cause of this fluctuation. This has been admirably summed up by Guilford (1927), who showed conclusively that the phenomenon had nothing to do with attention, but was a physiological function occurring only with liminal stimuli. A number of physiological conditions, both peripheral and central, were involved, among which were local retinal adaptation and eye movements, and local central fatigue and inhibition. A withdrawal of awareness occurs in other types of fatigue, particularly in that known as boredom; but this must be attributed to lapse of attention and to psychological inhibitory factors rather than to physiological factors. The bored individual has greater and greater difficulty in attending to the boring situation. This lapse of attention may sometimes occur rhythmically. Thus Wyatt and Fraser (1929) have demonstrated that rhythmical fluctuations of output occur in industrial workers suffering from boredom; and the greater the boredom, the more pronounced are the fluctuations.

Other phenomena of fluctuating awareness seem to depend partly on physiological factors, but to be greatly influenced by psychological factors also. The first of these is the alternation in awareness of the fields perceived by the eyes in *binocular retinal rivalry*. Thus if the unlikeness of the two retinal fields be made greater than is ordinarily the case in the binocular disparity of stereoscopic vision, either there may be diplopia, when the two fields appear superimposed; or one field alternates with the other in awareness. If the two fields are approximately equal in 'figural' qualities, this alternation, called retinal rivalry, will occur. According to Gellhorn (1928) it increases with the disparity between the two fields. If one field is more 'figural' than the other, the period of dominance of the former will increase and that of the latter diminish, until finally the latter may be suppressed altogether. Again, Breese (1909) found that the smaller field, for instance the smaller of two coloured squares, showed a longer period of dominance than the larger. An attentional attitude on the part of the observer particularly, according to Breese (1899), if reinforced by movements of the eye over the field, has the same effect, but will seldom produce complete dominance. A contoured field has complete dominance over a plain one (Kuroda, 1925), even if the latter, according to Hartridge (1915), has many times the physical intensity of the former. Apart from its structural qualities, the field of greater brightness, colour, saturation, colour contrast with background (Gellhorn, 1928), clearness, movingness, etc., tends to dominate over the field possessing less of these qualities. A variety of phenomena occur if plain fields of different wave-lengths are presented to the two eyes. If the absolute brightness is not too great, and if the brightness difference is reduced, mixture may take place. Pickford (1947) investigated the phenomenon by presenting colour filters stereoscopically in pairs, and instructing his observers to estimate the degree of fusion numerically, between 1·0 for perfect fusion, and 0 for complete absence of fusion. He found that some degree of combination occurred in all cases, but that bright colours were difficult to combine with dark. In general, colours near together in the spectrum were easy to combine. The difficulty of fusion increased as the colours reached the complementaries, but decreased again when they were still further apart. Hartridge (1950) confirmed this effect, but found that binocular fusion of complementaries became easier as illumination intensity was increased from 1 f.c. to 100 f.c.s.

With colours which are hard to fuse, rivalry is likely to occur. According to Johannsen (1930), the longer wave-lengths tend to dominate over the shorter; Kuroda (1925) also found that yellow and red possessed more dominating power than blue, white than black. Sometimes when difference is of brightness rather than of wave-length, for instance with white and black, the phenomenon of lustre is seen. It appears that all these phenomena, however, are extremely labile, differing at different times in different observers, and with different attitudinal factors. It may be true that, as McDougall (1903) held, they are in part due to conditions of inhibition in the central nervous system which are not under voluntary control, since voluntary direction and reinforcement of awareness cannot entirely suppress them. Like so many of the Gestalt phenomena, they seemed to be partly governed by the Law of Prägnanz; thus the most structured and 'impressive' fields tend to dominate.

Similar phenomena occur when there is a similar ambiguity in the 'figural' qualities of parts of the same field perceived simultaneously by both eyes. The *alternating 'figure'* and *'ground'* figures of Rubin (1921) and Köhler (1929) are almost too well known to require description. In Rubin's figures, an irregularly shaped white patch was presented on a black field. Sometimes the observer saw the patch spontaneously as 'figure', sometimes as 'ground'; and whichever aspect was perceived as 'figural' was the better remembered and recognized. In Köhler's T and flower pattern, and in the figure of the cup and faces, some observers will tend at the beginning to see one aspect as 'figural', and other observers will see the other. If the observers' attention is directed beforehand to the white or the black part of the pattern, that part will usually be seen as 'figural'. But generally, sooner or later, an alternation will occur and the other aspect be seen as 'figural'. The objective conditions which assist the dominance of one part of the field as 'figure' have been studied by Graham (1929), using the reversible sector figure (see Fig. 25). He found that there was a tendency to choose as 'figure' the system of smaller fields, in this case the narrower sectors; the smaller they were made, the stronger became this tendency. But this influence of area was greatly affected if the two fields were of unequal brightness; if brightness differences were great enough, the brighter field tended to dominate. These results were obtained by using colours of unequal brightness; colour itself did not seem greatly to affect the amount of dominance of one field over the other, either when two colours were compared together or one colour compared with white. Spatial position, above or below, left or right, may also produce an effect. Goldhamer (1934) repeated this investigation, using rather a different method; the figure was exposed in a Dodge tachistoscope for one second, and the observer required to report which part of it stood out. He confirmed the importance of relative area; there was a strong tendency for the smaller spatial sectors to dominate. This result is probably closely related to the principle enunciated by Rubin that if one area encloses another, the former tends to become the 'ground', the latter the 'figure'. Hornbostel (1922) also considered that the 'ground' tends to be concave, inward-reaching, embracing; the 'figure' convex, outward-moving, aggressive.

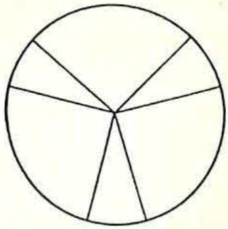


Fig. 25. The reversible sector-figure.

Spatial position in the ambiguous sector figure was also important; if one of the sectors, either in the lower or the upper half of the circle, was in the vertical position, that set of sectors tended to dominate. Black sectors also tended to dominate over white; but neither position nor blackness were as important as area. Goldhamer considered that the dominance of the black sectors disproved Graham's results with regard to brightness, but actually it seems unlikely that brightness effects entered very much into consideration in Goldhamer's experiment. Phenomenally, black and white would appear as different colours, and the black might tend to dominate, since, as Graham pointed out, the observer's previous experience with printed material and black-and-white drawings might create a 'set' for seeing black as 'figural'. Ehrenstein (1928), however, found that colour was more important in producing dominance than either form or size, except that angularity in itself was often a dominant. Symmetry also may produce dominance. Bahnsen (1928) showed two black and white figures, in one of which the white pattern was symmetrical, in the other the black. One set of observers was shown one figure, another the other, and 89 per cent of cases in all saw the symmetrical pattern as 'figure'.

A third type of phenomenon exhibits similar alternation of perceptual pattern: the *alternation* of *perspective* seen with ambiguous perspective figures. There are a number of these figures, of which those shown in Fig. 26 are the best known. Again, different observers will tend at first to see the perspective in some cases as projecting, in others as receding. But with prolonged fixation, an alternation to the opposite direction will occur. Flugel (1913b) showed that the alternation was not due to eye movements or to local retinal fatigue. Voluntary direction of awareness towards one perspective aspect rather than the other increased the period of dominance of that part; but the extent of voluntary control varied in different individuals, and was never complete. Complicating detail and enhancement of figural qualities also increased dominance, provided that these were such as to attract attention (Flugel, 1913a).

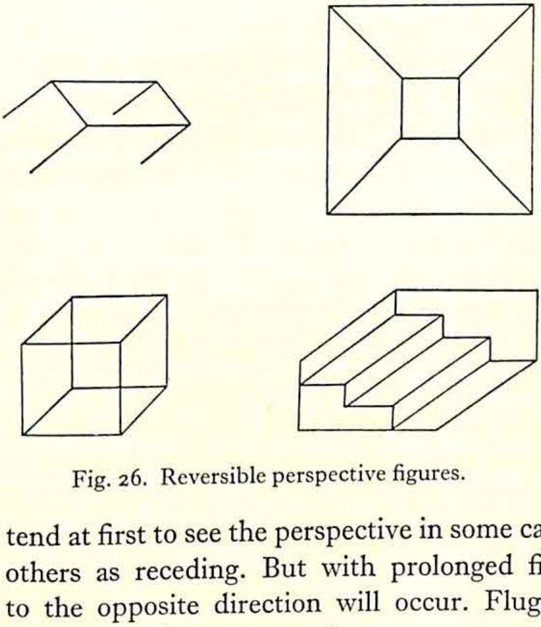


Fig. 26. Reversible perspective figures.

But experiments of Donahue and Griffitts (1931), and of Washburn, Reagan and Thurston (1934), seemed to show that simple, clearly defined and familiar figures might be more easily controlled and maintained at the focus of awareness than rather complex or vague figures which could not be readily imaged by the observer. However, the ability of the observer to comprehend such figures fully and to image them clearly might increase with practice, and then the rate of alternation would also increase.

Now it is of course true that whenever we view a varied perceptual field, the degree of awareness will differ for different parts of the field, and will change from time to time according to the degree of voluntary attention, the latter being determined largely by interest. But though we may not be conscious of changing our direction of awareness, such changes are not of the same nature as are the spontaneous rhythmical fluctuations of awareness which occur with liminal stimuli, retinal rivalry and alternating perspective. Some process of alternating excitation and inhibition must take place in the central nervous system, which is only partly under voluntary control, and is beneath the level of awareness.

(3) VOLUNTARY ATTENTION

But phenomena such as we have just described are rare in natural surroundings outside the laboratory situation. In general, awareness is directed towards those parts of the field which are of the greatest interest to the observer. These become 'figural', with the remainder of the field constituting the 'ground' and held at the margin of awareness. Changes in the external field will produce corresponding changes in the direction of awareness. Or the observer's interest changes or flags, or a rival interest supervenes, and again the direction of awareness will tend to change. But here a variety of motives may come into play and conflict with one another, until usually one or other proves the strongest, and sets in motion the process we know as voluntary attention, maintaining awareness of some part of the field rather than of others. This canalization of awareness in voluntary attention is a process which can be achieved only by learning and maturation. In the infant it is conspicuously absent, so that except in states of violent need his awareness rarely remains directed on one part of the field for more than a very short period of time. As interests develop, so also does power of attention; but some people do not fully attain it even in adult life. The improvement which occurs with practice and experience is amply demonstrated in the ability of the artist, the skilled craftsman, the inspector of industrial material, to direct awareness towards parts of the field not perceptible to the unpractised individual, and to maintain it there for long periods of time.

In laboratory experiments, the experimenter usually assumes the observer's co-operation in the attentional direction of his awareness towards the general aspects of the experimental situation, and considers it unnecessary to give him actual instructions on this point, reserving such instructions for dealing with particular tasks or aspects of the situation. And within limits, as we have already mentioned, this assumption is justified. Thus Meisenheimer (1929) found that, in a normal experimental situation, all percepts appeared at the focus of awareness and developed there; afterwards they might continue to exist outside the focus in a wider field of awareness, and remain there until awareness was again focused upon them. That is to say, experimental instructions to report the objects perceived at any moment were sufficient to cause the observer who had adopted the attentional attitude to direct his awareness towards the objects. But the experimenter may also have occasion to instruct the observer to concentrate his awareness upon some particular part or aspect of the experimental field, or to distribute awareness more widely over certain areas of the field, or even over its whole area, according to the type of result he desires to obtain. This is particularly necessary in visual experiments, since in visual perception the centre of awareness is usually situated in the neighbourhood of the point upon which the eyes are focused. If the experimenter therefore requires awareness to be directed to some other part or parts of the field, he must give explicit instructions to that effect.

Now it has been found that the more narrowly confined the awareness, the greater the clearness and accuracy of perception within its range, and the more vague and unclear the perception without it. Thus Hylan (1903) found that when an observer had to react, by pressing a key, to the appearance of a visual stimulus behind any one of six holes, his reaction time was shorter and less variable if he was instructed beforehand as to the hole behind which it would appear. If not instructed, his awareness was not concentrated upon that hole, but might be centred elsewhere, or generally distributed, making his reaction long and irregular. Similarly, Meisenheimer (1929), exposing digits at various positions in the visual periphery, found that if awareness was concentrated at some other part of the field than that at which the digit was to be exposed, the latter was less likely to be perceived accurately. Guratzsch (1929), using a similar method, with awareness either (1) distributed over the whole field, or (2) concentrated at the centre of vision, or (3) concentrated on a peripheral point, found that when awareness was concentrated on a single point, the loss in clearness of the rest of the field was greater than the gain in clearness of the point observed.

On the other hand, the more widely distributed the awareness over the field, the less the accuracy of perception of any one part of it. Thus Grindley (1931) found that the nature of a peripherally exposed test object was much less likely to be accurately reported if several other objects were also exposed simultaneously in the field, for the observer was obliged to distribute his awareness in order to perceive these other objects. It is thus natural that to perceive clearly and accurately the observer who voluntarily adopts the attentional attitude tries to narrow the range of awareness as far as possible, and to resist attempts to distribute or divide it. This is why, in viewing a complex field, we tend to group and unify diversity, so that awareness may be as narrowly concentrated as possible.

If, owing to the complexity or incongruity of the various stimuli, this combination is impossible, the attentional attitude will usually lead to successive focusing of awareness upon different parts or aspects of the field, each of which can be separately and satisfactorily dealt with, assimilated, and comprehended. If, as in tachistoscopic perception, this successive direction of awareness to different parts of the stimulus field is precluded, the observer may utilize instead the primary memory image. This process has been referred to before; thus in the experiment of Oberly (1924), described in Section (1) of this chapter, in estimating the number of dots on a card observers frequently counted them off successively from the primary memory image. McQueen (1917) found the same process to occur if the observer were required to report which was the largest of four circles exposed tachistoscopically; that is to say the observer compared the sizes of the memory images, not of the percepts.

On certain occasions, however, the observer may voluntarily seek to widen his range of awareness to include simultaneously two or more stimulus fields so different and unrelated that they cannot be combined or unified in any way. This process has been called the 'dissociation' or 'division of attention', and appears to consist largely of a rhythmical oscillation in the direction of awareness, which alternates rapidly between the different fields. This very rapid rhythmical oscillation of awareness, which can take place only with the most powerful attentional reinforcement, must in no way be confused with the much slower alternation, called 'spontaneous fluctuation of attention', which we have already described; for it was shown that the latter occurred in the absence of attentional reinforcement, and indeed did not appear to have any necessary relationship to attention. The rhythmical nature of the process of dissociation or division of attention was demonstrated by Hylan (1903), who required his observers to count the number of lines in two or more series exposed simultaneously through slits by revolving drums, slowing down the rate of revolution until the observers could count accurately. Hylan found that the 'counting time' was actually less with two or three series than with a single one, since the observers had no difficulty in alternating rhythmically between the two or three, after a certain amount of practice. But with a very irregular triple series in which no rhythm could be developed, the time was almost twice as long. There is little doubt that a similar rhythmical oscillation of attention occurs when a number of motor tasks are being performed simultaneously.

It appears that with practice the observer is sometimes able to perceive objects without directing his awareness fully upon them, that it to say, he is able to employ a non-focal type of awareness. Thus it was found by the author (1933) that much practice in the peripheral visual perception of a moving object enabled observers to note whether it moved or not without any focusing of awareness on it. Meanwhile their awareness was actually centred upon a complicated stationary figure perceived in foveal vision. Thus the perception of the peripherally exposed object had become to some extent automatized. The same thing of course occurs in the performance of two motor tasks, if the two tasks are sufficiently disparate. But if the two tasks are to some extent similar, complete dissociation with automatization of one or both may be impossible, and there is a tendency towards alternation, with possible confusion between the two motor activities. But, as Hylan (1903) points out, similarity is an advantage with two perceptual activities; thus it is easier to count two series of lines seen simultaneously, or of clicks heard, or of touches felt, than a series of lines and a series of clicks, and so on. In the first case it is possible to fuse the two perceptual activities, and to count the stimuli together.

Numerous investigations have been made of the time taken to change the direction of awareness from one stimulus to another. It is usually assumed that this period is equal to the least time which can elapse between the presentation of two stimuli such that each is accurately perceived, less the time taken by the actual development or 'clearing up' of the second percept. Feilgenhauer (1912) worked with momentary visual, auditory, and tactile stimuli, produced by electric sparks, with various periods of time between stimuli. The shortest time compatible with perception of both stimuli was about 300 σ, but this appears to have included also the time for development of the second percept. The speed of change of attention seemed to be about the same whether the stimuli belonged to the same or to different sensory modes, except that the minimum period was 35 σ longer when the first stimulus was visual, on account of the time taken for the after-sensation to disappear. But the shifting of attention was reported to be a smooth gliding process with stimuli of the same sensory mode, and irregular and sudden with stimuli of different sensory modes. The speed could not be voluntarily accelerated, though it could be voluntarily retarded. It varied with the individual and with his condition of health, but not with the intensity of stimulation. Mager (1925) also found that the smallest time for shift of attention was independent of the material or sense modality. His observers were required to judge differences in the intensity of visual or tactile stimuli at the first presentation, differences in intensity or number of stimuli at the second presentation. The second presentation was reported to overlap the first with a time interval of 200 σ; to overlap in 50 per cent of cases with an interval of 400 σ; and not to overlap with an interval of 600 σ. Mager calculated that the least time for shift of attention was 190–270 σ. This period was less than that of Feilgenhauer, since it did not include the time of development of the second percept. Bethe (1908) found that the minimum time for change of attention from one part of the visual field to another was 170–200 σ; his figures thus agree with those of Mager. Therefore these results are interesting in that they indicate the existence of a process occupying a finite period of time, which is not simply the development of the perception, but is apparently occupied by the actual change of direction of awareness from one percept to another.

The importance of the length of time required for change of awareness has recently been brought out in a series of experiments carried out by members of the Applied Psychology Unit at the Cambridge Psychological Laboratory. It was found that in general if an individual was called upon to react in different ways to two stimuli separated by a brief interval of time, of the order of 200 σ, the response to the second stimulus might be modified or inhibited by the response to the first. Now it was not clear at first whether the observer was prevented by his response to the first stimulus from observing, or from responding to, the second stimulus correctly. A recent report by Poulton (1950a) seems to indicate that the difficulty lay in re-directing awareness from the first response to the second stimulus and response. In Poulton's experiment, two different stimuli, a bell and a hammer blow, were given, and the observer was instructed to respond quickly to both by tracing along a track with a stylus. But in some cases, one or other of the stimuli was omitted, without any foreknowledge on the part of the observer. It was found that the observers could in general react correctly and quickly to a second stimulus given 400 σ after the first; and could frequently do so when the time interval was only 200 σ. But if they were uncertain as to whether or not the second stimulus would appear, their reactions to it were much slower. If a stimulus was given just before that to which the observer was to respond, and if he had been told to neglect this first stimulus, then his response was quick and accurate. Thus lack of readiness to respond was not due to lack of time to get ready, or to distraction, but to lack of knowledge whether there was anything for which to get ready. It seems therefore that the important feature in change of awareness is that the observer shall know what he is expected to perceive and do. If he does know, the change can take place in a short period of the order of 200 σ; if he does not, it will take much longer. In further experiments, Poulton (1950b and c) has shown the importance of expectation in the spatial direction of awareness. Thus when an observer was required to follow the course of an object moving along an irregular track or at an irregular speed, his accuracy in 'tracking' the object depended upon the extent to which he was able to anticipate the course. A frame of reference to the movement, or some pre-view of the track, were both helpful. Even unpractised observers made some hypothesis as to what they would have to do. In these they were guided by the assumption that the moving object would continue on much the same course and at much the same speed as were perceived during the earlier stages of the task. Errors of 'tracking' were then corrected by frequent checking against the actual movement which followed. This process also, therefore, was dependent upon rapid change in the direction of awareness.

(4) 'SET' AND 'AUFGABE'

It is clear then that the voluntary direction of awareness is improved, not only by experience and by motivation, but also by 'knowing what to look for'. Hence the importance of expert tuition in teaching the beginner to look for, that is to say, to direct his awareness towards, certain particular features of the situation, rather than to maintain a general alertness to the situation as a whole. He may have to look for certain stimuli which are so small or weak or lacking in 'figural' properties that they are difficult to perceive at any time. Or he may have to select and isolate certain features from a complex percept, observing these alone and ignoring the remainder of the field, in the manner described in the last section. In either case, he may be 'set' to perceive certain particular features in the total situation. What occurs in such cases has been well illustrated by the numerous experiments on 'set'.

According to Külpe (1904) and other workers, what is perceived in any given field is determined to a greater or less degree by a 'determining tendency', itself a function of the experimental task or *Aufgabe*; and is only in part a function of the immediate stimulus field. Külpe (1904) exposed to his observers groups of four nonsense syllables printed in four different colours and arranged in different groupings; he instructed them to observe and reproduce as many as possible afterwards, and on certain occasions gave them one of four special tasks:

(1) To discover the number of letters visible;
(2) To note the colours and position of the colours;
(3) To note the form and arrangement of the syllables;
(4) To discover as many letters as possible, noting their spatial position.

He found that the number and nature of the elements reproduced was largely a function of the assigned task; the elements non-accentuated were frequently forgotten, and the observer sometimes thought that they had never even appeared. As Gibson puts it (1941), a 'set' to perceive a particular stimulus may give it a 'prior entry' over stimuli of the same modality. But usually some vague perception of other features than those accentuated occurs, as is shown by the results of Boring (1924). He found that observers, instructed to compare either the relative intensity, or the relative extent, of two bright rectangles exposed tachistoscopically, were yet able to give some sort of secondary judgement as to the attribute which they had not been instructed to notice; though this judgement was not of course so accurate as the primary judgement. To obtain the secondary judgement they either utilized the primary memory image, or else re-imaged the original percept as a normal visual image. Chapman (1932) obtained similar results. He presented stimuli consisting of differently arranged groups of letters. In one series he gave instructions before the presentation of the stimulus, and in another, afterwards. The instructions were to report (1) the number of letters, or (2) the positions of the letters, or (3) what the letters were. When instructions were given before, the accuracy of report was greater, since the relevant aspects of the perceptual field were accentuated. When instructions were given afterwards, a mass of unnecessary imagery had to be held in suspension until the observer was instructed as to which aspect to select. Wilcocks (1925) asked one question after each exposure, in addition to giving a special instruction before it, and found that it was desirable for the question to coincide with the instructed task. Otherwise there was a strong conflict in awareness between the features selected according to the instructions and the features demanded by the question, and the reports were even less accurate than those produced by purely general instructions. Again, Kingsley (1932) found that if observers were instructed to search for a given feature in a complex picture, they often developed a perceptual 'set' to see that object in a particular way. The 'set' might even be carried in the form of a visual image of the expected object. If the object then appeared in a different way, it might be overlooked. For instance, when instructed to look for a 'turkey', they looked for a whole turkey, and overlooked a turkey's head. When shown a picture of the object beforehand, they might still overlook it if it appeared subsequently in a general setting which was different from that expected.

The greater the number of features which the observer is instructed to note, the less efficient the perception. Thus Dallenbach (1928) obtained the following results for the tachistoscopic perception of coloured forms or letters:

Observers required to report	*No. reported*
No. of stimuli	8–12
No. and names of letters	6–8
No. and shapes of forms	4
No., colours, and shapes of forms	3

Similarly, Postman and Bruner (1949) compared the effects of 'multiple set' and 'single set'. Pairs of words slanting across each other at an angle of 45 degrees were presented tachistoscopically. For the 'single set' group of observers, one of these words denoted a colour, the other being neutral; and they were instructed to read the colour word. For the 'multiple set' group of observers, one of the words denoted either a colour or a food, the other being neutral; and they had to read the colour or the food word. The time of exposure was increased until the test word was read correctly. The average time to perceive the colour words was 191 σ for the 'single set' group, and 228 σ for the 'multiple set' group. Moreover, observers in the second group were slower to formulate meaningful hypotheses as to the identity of the required words; and were more liable to produce completely 'blank' responses. They were less clearly orientated towards the task, and therefore more confused in their responses.

These results are complementary to those obtained for the range of awareness, which showed that the more narrowly concentrated the awareness, the greater the accuracy of perception within it, and the less the accuracy of perception outside it.

A particular 'set' towards the perceptual field is sometimes adopted voluntarily by the observer himself. Such occurred, for instance, in Flugel's experiments on reversible perspective (1913a). Again, when Zigler (1920) presented to his observers geometrical figures which were gradually or instantaneously replaced by other figures, he found that the figure actually perceived after the change differed according as to whether the observer assumed a 'set' towards 'form' (when it received a 'form' meaning), or towards 'object' (when it assumed an 'object' meaning). Again, in the 'constancy' experiments, the observer may be 'set' to perceive the stimulus as the 'real object', or to attend predominantly to the retinal impression. The index of phenomenal regression will vary accordingly. These 'sets' depended partly on the attitude spontaneously adopted by the observer, which was to some extent a function of his intelligence and training and possibly also of his type of personality. But the 'sets' were also influenced by the method of experiment and the experimental instructions, sometimes without the experimenter being aware of this fact.

Somewhat similar types of spontaneously adopted 'set' have been found to occur in carrying out psycho-physical experiments. It is well known to all those who have performed psycho-physical experiments that an observer, comparing two stimuli which are at or near to subjective equality, will tend to be more hesitating in his report than in comparing two stimuli with supra-liminal differences between them. He will not only find it impossible to say that one stimulus appears greater or less than the other; he may also be uncertain if they are equal, and will report 'doubtful', or at best 'no difference'. Earlier experimentalists tried to prevent these responses, since in quantitative measurements it was difficult to know how they should be treated, and the observer was instructed always to give judgements of either 'greater' or 'less'. Judgements of 'doubtful' or 'equal' then became much fewer in number, a desirable event from the point of view of the objective results. But George (1917) found that such instructions were liable to 'secure constancy of expression of judgement at the cost of instability of attitude'; and that changes in attitude during a series of psycho-physical measurements might be responsible for serious anomalies in the objective results. From a careful study of the introspections given after making such a series of judgements (of loudness of sounds and lengths of lines), he concluded that it was possible for the observer to maintain a constant attitude throughout the series. Doubt and expectation, accompanying 'doubtful', 'either-or', and 'no difference' judgements, altered and destroyed this attitude. But with suitable instructions and training, the observers learnt to confine their judgements to 'greater', 'less', or 'equal' (or 'delayed equal'), all of which could be made with constant attitude. The type of judgement to be aimed at is not the reflective and deliberate secondary process of judgement, in which all the factors of the situation are taken into account, balanced, and weighed up, before final deduction is made. Such a process favours dispositional change. Most experimenters can confirm from their own experience that observers who habitually make this type of judgement are unreliable and variable in their objective results in psycho-physical experiments. The observer should rather aim at adopting a passive, unreflective attitude towards the experimental situation, without undue carefulness and expectancy—in fact, almost a detached mind. He should give immediate estimates, as far as possible almost 'snap' judgements, of the perceptual situation. These estimates should be based on experiences of the nature of Oberly's immediate level of 'attention' (see p. 202). Attitudes and judgement processes of this kind are easily maintained with comparative consistency throughout the experimental series; moreover, as George (1917) has shown, they preclude 'doubtful' judgements, and in all probability lessen the number of 'equal' judgements.

Some later experiments of Fernberger (1931) appeared to show that an observer adopting a suitable attitude was able with practice to evolve definite categories of judgement corresponding to the experimental instructions according as they stressed the importance of subjective certainty in making judgements of 'equal' or in making judgements of 'greater' or 'less'. With the former instructions, the number of 'equal' judgements and the interval of uncertainty between the upper and lower limens were both smaller than with the latter instructions, and also tended to decrease with practice. One may suppose that, once the limits of the categories of judgement have been established in consciousness, the observer is able to apply them automatically without the necessity of making deliberate judgements of each stimulation separately.

It has been held by Bentley (1934) that a change of 'set' is likely to occur whenever the process of simple perception and bare apprehension passes over into that of 'inspection' and scrutiny. At this point, self-instructions appear, accompanied in general by feelings of strain, to see details, to identify the stimulus object, to compare it with past experiences, and so on. The exact nature of the self-instructions is determined by the experimental instructions, the nature of the material, and by the observer's underlying attitude towards the experimental situation. But they become prominent only when the task is too difficult to accomplish by mere simple observation. Hunt (1935) performed a variety of perceptual experiments to demonstrate the occurrence of the process of 'inspection'; and showed that the difficulty of the task depended upon: (1) organic conditions such as the efficiency of the visual mechanism, general bodily efficiency and fatigue, (2) biographical conditions, individual familiarity with the material and situation, (3) extra-organic conditions constituted by the observer's ideas about the nature of the task. In psycho-physical experiments, inspection was liable to occur with liminal stimulus differences, both actual and expected, and also when anticipation of certain stimulus conditions was contradicted by the immediate perceptual evidence. But with prolonged repetition of the experiments, the observer ceased to reinforce the experimenter's instructions with self-instructions to inspect the stimuli closely. Strain was decreased and the performance proceeded with greater ease, precision, and accuracy. Thus it appears that both experimenter and observer should in experiments of this kind aim at obtaining immediate perception and at discouraging the inspection process. But it is doubtful if this can occur without prolonged practice on the part of the observer, however favourable the experimental instructions. In perceptual experiments in which the observer is required to report minute details, or to obtain the full meaning and significance of the percept, inspection must be a *sine qua non*. Here the observer's self-instructions will operate most powerfully, and the nature of the percept will be much influenced by their effectiveness and cogency.

Fernberger (1919), following the hypothesis of Martin and Müller (1899), investigated the existence of a sensory basis for the 'set' which determines the immediate estimates of psycho-physical experiments. Comparisons of lifted weights, loudness of sounds, length of lines, and darkness of greys were made by his observers, using the 'constant method'. After some practice, the processes underlying the comparisons seemed to become simplified, and one concludes that immediate estimates of the type described above were in fact being given. In the comparison of greys, the two grey patches could be seen simultaneously, either in whole or in part, and the basis of the comparison was usually an immediate perception of equality or difference, with immediate verbal formulation of this equality or difference. But in the other series, owing to the separation either in time or space of the two stimuli compared, comparison was necessarily successive. It was found that in general a kinaesthetic 'set' was adopted as an immediate response to the first stimulus of the pair; and that at the advent of the second stimulus this 'set' was re-activated to produce an actual muscular innervation, with corresponding sensations of muscular strain. If this strain was increased in response to the second stimulus, a report of 'greater' was indicated; a relaxation indicated a report of 'less'. An 'equal' report was sometimes made as a direct conclusion from a continuance of the same degree of muscular strain. But more often there occurred a verification experience consisting of a perceptual or imaginal reference to the first member of the pair; perceptual in the comparison of lines when both members were simultaneously present, and imaginal in the weight-lifting and auditory experiments when they were not. This verification experience would then in all probability be the concomitant of the altered attitude of doubt and deliberation described by George (1917); while the immediate response of 'equal' without alteration of attitude would occur when the estimate was based purely on the sensations of strain.

The location of this muscular innervation was different for the different sensory stimuli. In weight-lifting it was located chiefly in the arm; in the comparison of length of lines, in the eye-muscles, intra- and extra-ocular; in the comparison of sounds, a more general contraction and relaxation of the musculature occurred—contraction for high sounds, relaxation for low ones. Whether it is possible to employ a kinaesthetic 'set' of this kind in all psycho-physical measurements can be determined only by experiment. In a successive comparison of visual colour or brightness it might be somewhat difficult; awareness of kinaesthetic sensation in response to light rarely exists, since we are not normally conscious of the contraction of the ciliary muscles. The direct employment of kinaesthetic sensory experience even in weight-lifting seems somewhat doubtful, however, in the light of Reid's experimental results (1924). His observers found great difficulty in using pressure patterns either on the fingers or on the wrist as a basis for their comparisons of lifted weights. They not infrequently disobeyed the instructions to use these sensory patterns alone, and returned to the more habitual mode of immediate comparison of the heaviness of the objectified weights. When they did manage to obey instructions to use purely kinaesthetic data, the differential limens were raised.

It is clear from these results that the experimenter cannot assume that the self-instructions and the 'set' of the observer will necessarily conform exactly to experimental instructions. The task may be too difficult for him to perform. It is not unlikely that the results of a good many perceptual experiments have been vitiated by the observer's struggles to carry out some task which is either psychologically impossible, or so complicated and difficult as to be of necessity imperfectly performed. The failure to carry out accurately even simple instructions directed towards the observer's attitude has been demonstrated by Anderson (1930). He directed his observers to adopt voluntarily one of a number of attitudes or 'sets' which they had previously shown they could adopt spontaneously, in perceiving simple and complex colours and tones. The attitudes were: (1) casual survey of stimulus objects, (2) inquiring survey of objects, (3) critical survey by the observer of himself observing, (4) critical particularizing survey of objects for accurate description, (5) personal valuation, in terms of pleasantness and unpleasantness, and (6) impersonal evaluation of objects as conforming to some conventional standard. The observers found that attitude (3) was impossible to adopt deliberately; and in only about half the observations were they able to carry out the function corresponding to the other instructed attitudes, for instance, critical survey, or impersonal valuation. Moreover, they were unable to maintain the same attitude throughout even a ten-second exposure; an average number of 2·3 attitudes occurred per exposure. Attitude (1) was prepotent with visual stimuli—that is to say, it was the easiest to adopt, and its function appeared most frequently; attitude (4) was prepotent with auditory stimuli. But there were many individual differences. Thus clearly the 'sets' or attitudes adopted and the procedure which actually occurred were functions of the experimental material and of the individual's inherent characteristics, as well as of the experimental instructions.

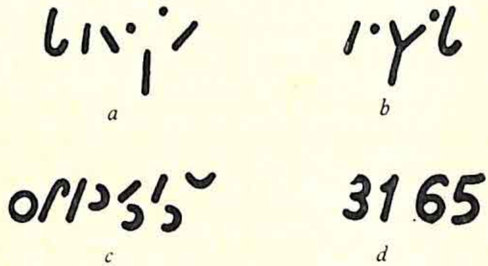
In this connection it is interesting to note the possible effects of 'ego-involvement' *v.* 'task-involvement'; that is to say, whether the observer considers the task to be a challenge to his own abilities and a possible threat to his self-esteem, or whether he regards it objectively and is concerned mainly with the performance in itself. Alper and Black (1949) have discussed the influence of these attitudes on learning performance, and the degree to which 'task-involvement' can be made to predominate by the nature of the instructions. It seems possible that, particularly with inexperienced observers, 'ego-involvement' may supervene in perceptual tasks also and produce a disruptive effect on performance. Some evidence on this point is given by the experiments of Verville (1946) described on p. 243.

However, it is also important to remember the effects upon results obtained which can occur in response to manipulation of instructions and to experimental setting; since these effects may assume some prominence if experimenter or observers have a strong theoretical bias. Frequently such a bias may have been created in the experimenter's mind by the theories of a particular 'school' of psychology. Such theories undoubtedly shape the training of students; hence the outlook of the latter and the techniques they adopt in carrying out experimental work. Thus they may almost unconsciously design their methods and instructions in such a way as to influence their experimental results. Either the observer may be led to produce the results which prove the theories with which the experimenter has been nurtured. Or he may be faced with a task which it is psychologically impossible for him to perform, as we described above. Or not infrequently the observer himself is thoroughly indoctrinated with the theories of that particular school, and may therefore be more than ready to produce the results required. It is invidious to give particular examples of the operation of this experimental bias, though numerous instances of its operation have appeared among the results described in this book. But since the bias often operates unconsciously, it may be difficult if not impossible to avoid. Hence it is always advisable to compare the results obtained by two or more experimenters from different schools of thought, before finally evaluating their conclusions.

But though any such general influences upon the observer's mind may be avoided, individual differences of previous knowledge, experience, and familiarity are unavoidable, and may be expected to operate in any perceptual experiment. We have already discussed the fact that perception as we know it cannot take place at all without some familiarity with previously encountered relevant situations. It is clear that in so far as these experiences are similar for different observers, as they are in great measure for individuals of the same type of upbringing and social background, then the perceptual experiences of these individuals will be similar. But the effect of familiarity, especially of prolonged familiarity, with experiences and situations peculiar to certain observers will be to cause their perceptual experiences to diverge from those of observers who have not become familiar with such situations. Every day instances of this truth are well known. The city-bred child does not recognize the animals and flowers which are readily perceived by the country child. The European does not perceive the tracks of wild animals which are obvious to the African native.

But familiarity is something more than a mere acquaintance with a particular situation or with the material of a laboratory experiment. It denotes the existence of some cognitive scheme of experienced phenomena into which the present percept fits. It is the nature of the relationship to such a scheme which supplies the meaning of the percept. Consequently the ability to understand the meaning of the percept is very closely related to its familiarity. And the feeling of ease or familiarity which often accompanies the act of perception is produced by the satisfaction of the conative drive designated by Bartlett the 'effort after meaning' (1916). Thus familiarity is constituted partly by a reaction to the cognitive aspects of the experimental material, and partly by the affective tone accompanying it. It may exist with all degrees of prominence, from that of extreme vagueness to that of complete determination and awareness.

Many experiments have been carried out in which the *effects of familiarity* have been demonstrated. Some of the earliest of these were performed by Cattell (1885) and by Goldscheider and Müller (1893). Cattell in his well-known experiments found that during a tachistoscopic exposure of 10 σ, the average reader could perceive three to four single letters or digits, two disconnected words containing up to twelve letters, or a sentence of four words. Now this increase in the number of letters perceived was due in part to the fact that the letters in the words were grouped together, and the words in the sentences; and as we have shown the effects of grouping are far-reaching. But it can also be shown that the number of letters perceived at a single glance when grouped as nonsense syllables is less than the number perceived when grouped as words; and if the words are familiar, the number perceived will be larger than if the words are unfamiliar. Thus it is the familiar act of reading and understanding words and sentences which enables the reader to note and report the larger number of letters. Goldscheider and Müller (1893) obtained similar results. They found that a group such as that shown in Fig. 27 *a* had to be exposed seven times before it could be reproduced, while the same shapes arranged as in Fig. 27 *b* could be perceived and reproduced at the first or second glance. Again, the group in Fig. 27 *d* could be perceived with one or two exposures; but only four or five of the constituent parts, arranged as in



a *b*

c *d*

Fig. 27. The effect of familiarity.

Fig. 27 *c*, could be seen at each exposure. Indeed there is little doubt that our ability to read as rapidly and easily as we do is entirely dependent upon our extreme familiarity with the letter and word forms. Thus we do not need to perceive clearly and in detail every letter, or even every word, but are able to pick up vague outlines or structures of words and phrases which are a sufficient clue for perceiving and apprehending the meaning of the words. That this ability is closely related to familiarity with the actual visual structure of the printed material is shown by the fact that reading is greatly impeded by the use of a strange and unfamiliar type face. Thus experimental results from English readers show that they read Gothic Fraktur type more slowly and with greater difficulty than they read ordinary Roman type (Gilliland, 1927); but German readers on the other hand may have more difficulty with the Roman type, and read it more slowly than they read Fraktur (Wick, 1921).

Even a familiar object may, however, go unrecognized if the setting in which it appears is strange. Thus Feingold (1915) found that it was easier to recognize a previously seen word when it was presented with a group of words with which it had already appeared than when it was presented with a group of strange words, in the proportion of 12:1. The same result was obtained by Kingsley with pictorial material (see p. 216). Thus it is necessary for the whole setting to be familiar if perception and recognition are to be easy.

It is important to note, however, that a very familiar perceptual setting may go unnoticed, while an unfamiliar item introduced into that setting immediately enters awareness. Examples of this are common in everyday life; we are apparently quite unaware of the familiar surroundings of a room, house or street, but the removal of an accustomed object or the introduction of a new one is immediately noticed. Thus Feingold (1915) found that it was easier to recognize a new word in the same setting (a list of words which had already been presented) than the same word in a new setting, of words not previously presented, in the proportion of 27:1. But although the observer may readily become aware of the presence of an unfamiliar object, he may perceive it simply as something unfamiliar, without observing or remembering its exact position or essential nature. Thus Bartlett (1916) found that in tachistoscopically presented figures, an unfamiliar feature was readily noticed, but its exact relationship and position in the figure rarely observed. Hence it is perceived simply as 'something different' in a familiar pattern—a variation in a well-known structure—without any apprehension of its identity as an item in itself. But this 'something different' must constitute a fairly striking deviation from the familiar pattern, otherwise, as we shall see below, it may be ignored altogether.

Familiarity with the experimental material, or with some particular aspect or part of it, may modify not only the phenomenal extent of the percept, but also its phenomenal nature. Thus Bartlett (1916) showed a figure consisting of a schematic and rather indefinite representation of an aeroplane, beneath which was printed, 'An Airoplaxe'. In all cases but two, however, the observers reported after the first or second glance that they saw an aeroplane, and in every case but one the writing was said to be, 'An Aeroplane'. The inability to notice mis-spellings and errors is very common in any type of reading. Pillsbury (1897) showed that the errors in misprinted words presented tachistoscopically were more readily ignored if some word of closely associated meaning was spoken just previously. The familiar context acted in the same way as the familiar aeroplane picture in Bartlett's example. The ignoring of defects was also demonstrated by Ross and Schilder (1934) in the tachistoscopic perception of drawings of the human figure. Certain parts were omitted from these forms, or extra features or limbs were added. At first the observer was usually unaware that any part was missing; he supplied it in accordance with his previous knowledge of the human form. Additional parts were ignored, or re-interpreted; for instance, an extra eye in the middle of the forehead was said to be a curl of hair. Again, Bruner and Postman (1949) found that when observers were shown tachistoscopically playing cards in which the colours were reversed (that is to say, red spades and clubs, black hearts and diamonds), they had great difficulty in perceiving them. In some cases either the suit or the colour was given in accordance with normal expectation, instead of that actually shown. In some cases there was a compromise, red being reported as purple, or black as greyish. In other cases, the observer was completely unable to make any identification. All observers were very slow to realize the reversal of colour.

These cases all show the effect of familiarity based upon deeply rooted and well-organized schemes of experience. But familiarity of a more superficial type may also affect subsequent perception. Braly (1933) has shown that observers who had previously been shown a set of figures of a certain type—for instance, triangles—tended to report and substitute this type more frequently in reproducing a test series of rectangles, triangles, and pentagons, than did observers who had not been shown the first set of figures. A similar effect was demonstrated in an ingenious experiment of Gottschaldt (1929). Using an episcotister with a gradually opening sector, he was able to expose figures with a gradually increasing degree of clearness, instructing the observer to stop him as soon as he saw something new appearing. Two main pairs of figures were used, which are shown in Fig. 28. In general the one marked *a ii* developed in such a way that the square was seen first and the dash later; *b ii* developed so that the circle was seen first and the arrowhead afterwards. But if *a i* and *b i* were presented a large number of times, followed respectively by *a ii* and *b ii*, then the cross and the arrow appeared before the square and the circle. Again, if a series of squares was presented, and then a series of crosses with *a ii* included among them, the cross in *a ii* appeared first, because a cross was expected. But if pairs of crosses were alternated with pairs of different figures, when a pair of crosses was followed by *a ii*, the square developed first, because something different from a cross was expected.

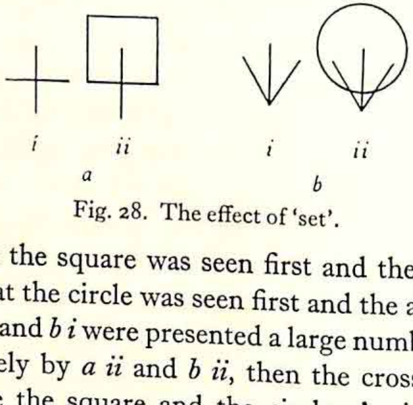


Fig. 28. The effect of 'set'.

Thus the method of development of the percept varied according to the previous experimental experience of the observer.

In the same way, Leeper (1935) found that if prior to the presentation of Boring's ambiguous 'wife and mother-in-law' figure (Boring, 1930; see Fig. 15, p. 71), one phase of that picture had been seen alone, then the same phase predominated when the whole figure was seen, to the exclusion of the other phase. Again, the Street incomplete figures (Street, 1931) were more readily perceived if the observer had previously been told the category to which they belonged ('animal', for instance). Siipola (1935) demonstrated the same effect in the perception of words. If the observer was 'set' to perceive names of animals, he perceived the nonsense syllables 'sael' and 'wharl' as 'seal' and 'whale'; if he was set to perceive something to do with boats, he perceived them as 'sail' and 'wharf'. Henle (1942) found that when observers were shown a preliminary series of reversed letters, then subsequently the number of reversed letters perceived during a short exposure, or in peripheral vision, of a mixed series of letters, reversed letters and meaningless shapes, was greater than when no such preliminary series had been given.

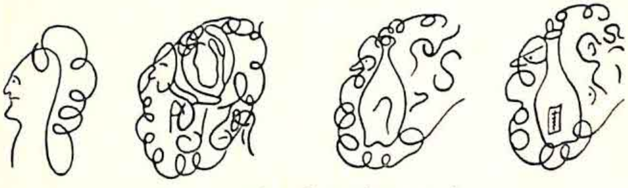


Fig. 29. The effect of suggestion.

Luchins (1945; see Fig. 29) and Hall (1950) showed series of figures in which one type of figure was gradually modified in successive presentations until it turned into another. The names given by the observers to the successive figures were considerably affected by the nature of the previously seen figures; and, in the case of Hall's adult observers, by anticipation of the development of the series. When names were given to the figures by the experimenter, this also affected the observers' subsequent reactions, acting as a suggestion as to what was to be perceived.

Another excellent example of the effect on perception of a specially arranged previous experience is given in an experiment by Russell Davis and Sinha (1950). They gave their observers to read a story which told of a feud between two families; a reconciliation in the betrothal of the son of one family to the daughter of the other; and the wedding feast which marked the somewhat uneasy truce. Three days after reading the story, the observers were shown a reproduction of 'The Village Wedding', by Pieter Brueghel, together with several other pictures, and were asked to pick out the picture which depicted an incident described in the story. All observers selected 'The Village Wedding'. Then on a subsequent occasion they were asked to recall the picture. It was found that this recall was greatly affected by the previously read story. Those features of the picture which best illustrated the story were stressed, while others were forgotten; and details of the picture were distorted or even replaced by items from the story. Moreover, the atmosphere of uneasiness suggested by the story was reflected in the descriptions of the picture. Whereas a control group, who had seen the picture but not read the story, saw the picture simply as a scene of gaiety and merriment. Here then is an example of a real change in the general atmosphere of the perceived material, and not merely of particular detail, which was produced by a related experience. It is true that the effect was much enhanced by remembering, since it grew as the period before recall was lengthened. But when the observers first selected 'The Village Wedding' from among the other pictures, it was clear from their comments that their perception of it was closely assimilated to their recollections of the story.

In general, however, the effects of familiarity are greater if some real scheme of knowledge has been set up into which the present percept can be fitted. Thus Fox (1924) carried out experiments in which he showed students pictures of armour and required them to report afterwards as much as they remembered of the pictures. He found that the students whom he first instructed in the details of the construction of armour were much more active in their subsequent perception of the pictures, and reported much more afterwards than those who had received no such instruction. But this only occurred when the students had thoroughly understood and digested the previous instruction; otherwise, they were muddled by it and not assisted.

A different kind of scheme was instanced in Chapter VII as determining the results of psycho-physical experiments. It was shown that the observer frequently established both long- and short-term standards or 'levels' of, for instance, heaviness and lightness of weights lifted during the psycho-physical experiment. The short-term 'level' was based upon the range of weights actually lifted during the experiment; and the long-term 'level' by the observer's general standards of heaviness and lightness established by lifting objects in everyday life. His judgements of 'heavy' and 'light' were then referred to these 'levels'.

Thus it appears that the influence of 'set' may in fact take place through familiarity with the experimental conditions, with what to perceive or look for; through a pre-perception or partial acquaintance with the meaning of the perceptual content. Hence the full apprehension of that meaning, which is the final end and completion of the perceptual act, is mediated and assisted along lines indicated by the pre-perception. And the pre-perception creates an expectation of what is to come. The expectation can be aroused, as Gibson (1941) says, by instructions, training or a regular sequence of events which may have a non-verbalized, even an unconscious, effect. However, the more fundamental and far-reaching the cognitive scheme within which the pre-perception operates, the more profound its effect upon the perceptual act, and the more complete its determination thereof. The same is true of familiarity and experience of a more casual and less systematic kind; as Wertheimer says (1945, p. 62): 'The role of past experience is of high importance, but what matters is *what* one has gained from experience—blind un-understood connections, or insight into structural inner relatedness.'

(5) THE STUDY OF MOTIVATIONAL FACTORS

We must now consider other factors functioning in the perceptual process which are more individual, personal and subjective, and less purely cognitive than those which we have just discussed. Here we enter upon a field of study which has only recently received much attention, and of which little is definitely known. What has been clear since the work of Bartlett (1916) is that even quite simple perceptual material may be perceived differently by different observers. With more complex material, the differences may be outstanding; some examples obtained by the author are given in Appendix B (p. 262). These differences have been ascribed partly to familiarity with previous experience, as we have just discussed; and partly to differing attitudes and interests. The terms 'attitude' and 'interest' have often, however, been used merely as an acknowledgement of the existence of individual differences in perceiving, and little has been done to discover the nature of the attitudes and interests, or the manner in which they determine the individual's perceptions.

Quite recently, however, a number of experimental studies have been made of the relation of specific *motivation* to perception—in some cases of motivation already existent in the observer, and in other cases of motivation created deliberately by the experimenter. But it must be recognized firstly that motivation of some kind is inherent in the performance of any laboratory experiment, although the differences in such motivation have not often been studied. The experimenter usually assumes that his observer is prepared to undertake what may in fact be quite a difficult task, involving effort and endurance. This effort is perhaps more obvious in experiments on learning than in experiments on perceiving. But unless the observer is prepared and willing to act, he may in fact perceive very little of what is presented to him. This preparedness has sometimes been recognized to exist and has been termed 'organic set'. For instance, Young (1925) postulated 'organic set' as being an integrated neural and muscular pattern of adjustment operating in both physical and mental activities, and purposive in nature. In laboratory experiments on perceiving, the purpose would be towards perceiving as quickly and as accurately as possible the material presented. Dashiell (1940) stressed the point that such 'sets' involve readiness to react, and are characterized by heightened muscular tension. Gibson (1941) stated that the concept of 'set' as used by American psychologists implies a specific and drive-controlled habit, usually acquired by learning. Although Young and Dashiell did not deal with the effects of such 'sets' upon perception, and Gibson appears to have done so only by implication, yet, as we mentioned on p. 27, Rogers (1917) noted the appearance of kinaesthetic and organic sensation during the perceptual process. The functioning of the kinaesthetic sensation was to 'carry self-instructions either to seek meaning or determine the appropriateness of significance'. This seems to indicate the existence in laboratory experiments on perception of muscular tension accompanying the conative drive towards the achievement of the purpose of the experiment. But the work of Hunt (1935) and Bentley (1934) indicated that such tension was a function of the process of careful 'inspection' rather than of immediate perception. Thus these tensions may bear little relationship to the motivational factors which affect the perceptions of ordinary life.

Bartlett (1932) comments on the importance of inherent interests in directing perception. Indeed, he states categorically: 'The experiments (on perceiving) repeatedly demonstrate that temperament, interest, and attitudes often direct the course and determine the content of perceiving' (1932, p. 33). But the examples he gives are mainly of general modes of perceiving, which we shall study in the next section. He gives few specific instances of the operation of particular interests other than that of the mathematical student who remembered a series of wavy lines because they reminded him of a 'determinant' (see p. 40). But evidence for these statements is given by the experiments of Postman, Bruner and McGinnies (1948). In these, thirty-six words, chosen to represent the six 'values' of the Allport-Vernon 'Study of Values' test, were shown in exposures increasing from 0·01 second (in steps of 0·01 second) until identification occurred. The average time for correct identification was 0·065 second for words in the category on which the observer scored highest in the Allport-Vernon test; and it was 0·097 second for the words in the category on which he scored lowest. When words were guessed before complete identification was achieved, words equivalent in meaning were given in response to those in the highly valued category; whereas in response to words of the low-valued category, the words guessed were more often of different or even contradictory meaning.

In another study, Bruner and Postman (1947b) obtained the reaction times, in a free association test, to ninety-nine words, and then chose for each observer the six words to which he made the fastest reaction time, the six with the slowest, and six with intermediate reaction times. A fortnight later, the time taken to perceive these words was measured in the same way as in the previous experiment. It was found that with some observers the perception time became steadily greater the longer the original reaction time. But with others, the perception time reached a maximum with words of medium reaction time; and some of the words with the longest reaction times were very rapidly perceived. These were in general words with a high emotional value, including some with sexual connotations. Bruner and Postman considered that some observers made a defensive reaction in perceiving and hence were slow to identify these emotionally charged words. Others, however, were rendered vigilant and alert towards these words, and hence perceived them particularly rapidly. It seems possible that with the former group a partial identification caused a state of confusion and inhibition which retarded complete identification and the naming of the word.

It should be noted, however, that no check was made as to the relative familiarity of the various words perceived. It is possible therefore that the relatively quicker perception of the favoured words, particularly in the earlier experiment of Postman, Bruner and McGinnies, was due to the purely cognitive factor of greater familiarity. But it would of course be difficult to detect this effect, since familiarity varies from one individual to another.

Further evidence, however, was obtained by McGinnies (1949), who measured the psycho-galvanic responses of observers to eighteen tachistoscopically exposed words, seven of which had highly unpleasant sexual connotations. The psycho-galvanic response was measured before the observer reported the word he had seen. It was found that frequently an excessive response occurred to the unpleasant words even before they were accurately perceived—the perception time being on the whole slower than for the neutral words. Here again therefore there appeared to be an inhibiting force preventing the conscious awareness of words which are socially tabooed, although they had produced sufficient impression at a subconscious level to increase the psycho-galvanic response. There seems no reason to suppose that any unfamiliarity with the tabooed words could have affected the psycho-galvanic response.

Emotional attitudes towards perceptual performance may be introduced by *social* and *group attitudes*. The effect of conformity or suggestibility to group influence was shown in Sherif's study of the autokinetic effect (1936). Observers had to judge the extent of the autokinetic movement when working alone, or when working in a group of three or four people. When working alone, the individual usually established his own individual norm of the extent of movement, to which he adhered throughout subsequent experiments carried out alone. But when individuals worked in a group, their judgements of the extent of movement tended to resemble one another closely; and this group norm was maintained during subsequent experiments carried out by individuals working alone. Now it is clear that autokinetic movement is a labile phenomenon, not at all closely determined by the objective physical conditions.[1] Therefore group suggestion may operate upon it to a greater extent than can be expected in normal perceptual phenomena. Thus Münsterburg (1914) found that, in a class of 400 students, about one-third adapted their judgements of the number of dots on a card towards the group judgement; there was little or no effect of the group judgement on the majority. In this situation, direct suggestibility was less widely operative. Luchins (1945), however, demonstrated a considerable effect which resulted from the suggestion of one twelve-year-old child to another. A series of twelve drawings was presented, which began with a scribbled-over face which was gradually modified in successive presentations until the face disappeared and a bottle

[1] Haggard and Rose (1944), in discussing autokinetic movement, attribute it to 'streaming movements', by contrast with which a stationary point of light appears to move. But these streaming movements are said to occur in the cortex, and not in the retina; hence the possibility of voluntary control (see also p. 246).

could be seen (for examples, see Fig. 29, p. 229). Children were shown these figures and had to name each one in turn, or say what they saw in it. Each child in the experimental group was accompanied by a 'confederate', a child who had previously been instructed always to respond, 'a face'. Compared with a control group who received no such suggestion, the children in the experimental group gave more responses of 'face' and fewer of 'bottle'. From subsequent questioning, it appeared that in most cases they really had noticed the face and overlooked the bottle. However, this type of suggestion operated only because there was a definite indication of a face in the drawings. If the 'confederate' said 'battleship' or 'automobile', the other child showed no tendency to copy this suggestion. Thus clearly the perceptual configuration and the suggested name must agree to some extent for the latter to modify the former.

Frenkel-Brunswik (1949) considers that such ambiguous perceptions may be affected by generalized social attitudes such as race prejudice and rigid conformity to the attitudes and outlook of a particular social group. Children who showed such attitudes strongly were slow in noticing the change from one figure to another, when a succession of figures was shown gradually modifying from a picture of a dog to a picture of a cat. When at length they were obliged to abandon the 'dog' interpretation, there was a period of haphazard guessing, and inability to change to the 'cat' interpretation. The same phenomenon occurred with other figures. These were attributed to an 'intolerance of perceptual ambiguity', associated with the rigid social attitude of these children.

Apart from determining the nature of the perception, a group situation may have a favourable or unfavourable motivational effect on the speed or accuracy of perception of those working in it. F. H. Allport (1924), however, found that his observers' rate of alternation in reversible perspective was not altered by working in a group. Moede (1920) found that on the average the accuracy of judgement of the relative intensity of two sounds was the same for observers working in a group or alone, when they did not make their judgements known to each other. But the observers of high ability tended to judge less well in the group situation; those of poorer ability tended to do better. Presumably the poorer observers were stimulated by the presence of the better ones, while the better ones were distracted by the group situation. This seems to be a general characteristic of work done in groups.

An experiment performed by Bruner and Goodman (1947) seemed to indicate emotional effects which differed according to socio-economic status. They required ten-year-old children to adjust the size of a circle of light to equal the tactually perceived sizes of a series of coins and of cardboard discs held in the hand. The sizes of the discs were estimated correctly, but the sizes of the coins were over-estimated in proportion to their monetary value. The poorer children over-estimated the coins to a greater extent than did the richer children. These effects Bruner and Goodman attributed to the higher social value of the coins of higher denomination, especially to the poorer children. But over-estimation was at a maximum at twenty-five cents. The half-dollar was not over-estimated. According to Bruner and Postman, this was because it was almost too valuable to seem real. Adults over-estimated the sizes also, but showed no such reversal above twenty-five cents.

However, the experiment was repeated by Carter and Schooler (1949) with a somewhat different procedure and results. The children who were the observers in the experiment had to adjust the size of a circle of light to equal the sizes of coins and cardboard and aluminium discs which they perceived visually; and also to equal their recollections of the sizes of coins. In the case of the direct perception of the objects, there was a general tendency to under-estimate the sizes of all the smaller-sized coins and discs, and to over-estimate the sizes of the larger ones. Only in recollection were the sizes of the larger coins over-estimated to a greater extent than the sizes of the discs, and by the poorer children, not by the richer children. Thus Carter and Schooler, and also Pastore (1949), attribute the over-estimation in the experiment of Bruner and Goodman simply to a tendency to over-estimate larger-sized objects by comparison with smaller ones. In that experiment, the children who estimated the sizes of the coins were not the same as the children who estimated the sizes of the cardboard discs, and the two groups were not matched for accuracy of size estimation. Thus the rather surprising results of Bruner and Goodman cannot be altogether accepted.[1]

But a close linkage of over-estimation of size with value and reward was also demonstrated in an experiment by Lambert *et al.* (1949). Two groups of children aged three to five years were rewarded for performing the rather dreary task of turning a crank handle, the control group with pieces of 'candy', the experimental group with poker chips which they could subsequently put into a slot machine to obtain candy. Both groups later made size estimates of a poker chip. The control group showed no tendency to over-estimate its size, but the experimental group significantly over-estimated it. But when they were required to perform the task without reward, the over-estimation disappeared. With these young children, therefore, there was a close linkage between reward value and size estimation.

Comparable effects upon size estimation were demonstrated by Bruner and Postman (1947a) to result from the after-effects of electric shock. The size of a cardboard disc held in the hand was estimated with fair accuracy while the shock was actually in operation. But during the period after the shock was given, the size was over-estimated, apparently as the result of a state of expansiveness set up during recovery from the shock. Here then a positive influence was exerted by the contrast with a negative or frustrating situation. We shall discuss the immediate effects of frustration more fully below.

Ansbacher (1937) has described results obtained by himself and also of unpublished researches by Zuk-Kardos and Fazil, in which there appeared to be a general tendency as between two groups of postage stamps, or of coins, to over-estimate the size of the stamps in the group of larger stamps, and the size of the stamps or coins of larger denominations. But the *number* of stamps in the group of higher denominations tended at first to be under-estimated until the observers had been asked to estimate the relative monetary values of the two groups. Thereafter, there was a tendency to over-estimate the number of stamps of higher denominations. Ansbacher puts forward the theory that when two variables are involved, e.g. size of individual members of a group and size of group, size and number of individual members, value and number, even colour and number, then the estimation of one variable will tend to be confused by variations of the other variable. If judgement of one variable is particularly stressed, then subsequent estimation of the second variable will be proportionately affected. Postman and Page (1947) showed a similar effect with observers who were required: first, to compare the heights of a standard with that of variable rectangles which varied both in height and in width; secondly, to compare their widths; and thirdly, to compare their heights again. The judgements made at the third stage were less accurate than those made at the first stage. It seemed that the process of abstracting one variable from a complex situation affected the accuracy with which the other variable could be abstracted. The 'phenomenal compromise' in phenomenal regression experiments may, according to Brunswik (see Tolman, 1935), be another example of this interaction of two variables. This of course agrees with data described earlier, notably on pp. 51–4, which showed how difficult it is to judge accurately a single aspect of the total perceptual situation. But the isolation of a single aspect may be even harder when emotional tendencies exist to bias judgement.

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[1] However, Bruner later pointed out (see Blake and Ramsey, 1951, p. 140) that there is a widespread linkage in our culture between size and value. Thus over-estimation of size cues may be enhanced by over-estimation of value cues.

The effects of *social attitudes* were also demonstrated in the experiments of Seeleman (1940) and of Marks (1943). Seeleman carried out experiments on the perception and recognition by white students with pro- and anti-Negro attitudes of pictures of Negro and white faces. When asked to recognize faces previously shown, among a new set containing others not previously shown, students with a pro-Negro attitude recognized significantly more of the Negro faces than did those with an anti-Negro attitude. Since the period between the presentations of the two series was only ten minutes, it seems probable that this effect was due to perceptual rather than to memory differences. Indeed, it appeared from the students' introspections that those with a pro-Negro attitude saw the Negro faces as those of distinct individuals; while those with an anti-Negro attitude saw them simply as undifferentiated Negroes. Here then we have a more or less conscious direction of awareness towards or away from specific features of the perceptual situation. But it is reasonable to suppose that less conscious attitudes would usually have the same type of effect. This is indeed demonstrated in the work of Marks. In his experiments, groups of Negro students were asked to rate themselves and one another on a point scale of lightness and darkness of skin colour. They also had to rate one another on personal attractiveness, and to state what colour of skin they preferred. It was found that on the average the preferred colour was rather lighter than medium. Self-estimates of colour tended to fall between this preferred colour and the individual's actual colour. Thus the students were apt to make egocentrically biased estimates of a perceptual quality which was of great personal importance to them. In assessing the colour of others, there was a tendency to correlate degree of attractiveness and estimated skin colour. Those who judged a girl to be attractive placed her skin colour nearer to the preferred skin colour than did those who did not think her attractive.[1] There was also a tendency for all the ratings made by the darker individuals to be relatively lighter than those made by the lighter individuals. Marks suggests that each student tended to think of himself as 'average' in colour, and to scale others about himself as average. Thus if he were in fact much darker than average, he would tend to 'scale up' his own colour and hence shift his whole scale of ratings in the 'light' direction. This 'central tendency of judgement' seemed to scale assessments about a middle point which was the rater's estimate of his own skin colour, shifted, as we have seen, towards the preferred degree of colour.

Experiments have also been performed to show the direct effect on perception of *need tensions* and their satisfaction or frustration. It should be noted in the first place that such effects show up most clearly when the perceptual field is vague and relatively indefinite and unstructured; and when a strong imaginal component enters into its apprehension. Some experiments by Sanford (1936) showed the effect of hunger tension on purely imaginal tasks. Thus it appeared that a maximum number of responses relating to food were given in tests of free association and picture and word completion by individuals after a period of food deprivation and just before a main meal. In the experiments of McClelland and Atkinson (1948), observers were placed in front of a screen on which, they were told, pictures would be projected faintly, and they were to report what they saw. In most cases, nothing was actually projected on the screen; but in some cases, vague blots were shown. Again, more food-related responses were given after longer periods of food deprivation. But also (*a*) more food-related responses were given when nothing was shown than when blots were shown; and (*b*) more were given when it was hinted that objects were being shown than when other types of projection were suggested. Thus clearly the nature of the objective situation had a strong influence in controlling the imaging of food or food attributes.

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[1] This particular effect seemed to operate more with judgements about female students than about male students.

This appeared also in an experiment by Levine, Chein and Murphy (1942), in which forty coloured and forty black-and-white pictures were exposed behind ground glass which blurred the pictures. Some of the pictures represented food articles, others neutral objects or meaningless designs. As the period of food deprivation of the observers increased, the number of food responses increased also, up to a maximum at three hours after food for the coloured pictures and six hours after food for the black-and-white pictures. But the tendency to 'reject' the pictures, i.e. not to name them at all, increased steadily up to twenty-four hours after food deprivation. These various authors have put forward the theory that 'need tensions' produce an unconscious or 'autistic' tendency to image the desired object, and this tendency may conflict with the actual sensory attributes or form qualities of the stimulus object, in determining the final percept. In the experiment of Levine, Chein and Murphy, the autistic tendency was said to come sooner into conflict with the perception of the more 'realistic' coloured pictures—a supposition for which there seems to be little evidence. The decline in the number of food responses after a certain period of food deprivation may have been due to a weakening of hunger tension and hence of the autistic tendency; or possibly to a general boredom and disgust with the situation, that is to say, an alternative 'need tension', and hence the increasing number of 'rejections'.

In a later experiment by McClelland, Atkinson and Clark (1949), 'need tension' was said to be set up during the course of the experiment by frustration and sense of failure, and the desire to compensate for these. In the first part of the experiment, groups of students were given simple mental tests. Some of the students—the 'failure' group—were then told that performance in these was related to high intelligence, that such tests had actually been used for selection testing, and that a number of students from another University had obtained scores considerably higher than their own. A second group—the 'success' group—were told that the students from the other University had obtained scores considerably lower than their own. There was also a control group given no such instructions. After this, all three groups were shown projections of the type given in McClelland and Atkinson's food deprivation experiments, together with various suggestions as to what these presentations might be, and were asked questions about them. Apparently these students experienced sufficient autistic imagery of the objects suggested to be able to answer the questions.

It was found that in answer to questions such as 'There is a sum of money on the table; how much?' the 'failure' group reported larger sums than did the 'success' group. When it was suggested that a list of examination 'grades' had been shown, and they were asked how many people fell into the various grades, the 'success' group gave a larger estimate of the number of 'good' grades than did the 'failure' group. But when it was stated that a picture of a race was being shown, and the students were asked how many men were in front of the man in the dark uniform, the 'failure' group put fewer people in front of him than did the control and 'success' groups. McClelland *et al.* concluded that the 'failure' group tended to under-estimate signs of past achievement, such as examination 'grades'; but to overestimate the possibilities of future success, in running a race, or possessing a large sum of money. Interesting as these results are, the actual 'need tensions' at work and their mode of operation seem somewhat doubtful. Indeed, McClelland *et al.* themselves found that another set of students were apparently so overcome by the effects of apparent failure in the mental tests that they had great difficulty in answering the questions, presumably because they experienced so little suggested imagery.

Other evidence has been obtained as to the disruptive effect on perception of frustrating experiences. Thus Verville and Cameron (1946) found that a series of incomplete pictures similar to those of Street (1931) were identified and named more readily by younger than by older adults. The latter were said to be suspicious and apprehensive of the experimental situation, especially after initial failure, while the former were more curious and eager. Emotional attitudes were also set up by earlier experimental situations (Verville, 1946). Some observers were given tasks which it was quite impossible to perform in the time allowed, and these were slowest in naming the incomplete pictures subsequently. Those who had previously carried out personality tests were also slower than normal; but this may have been due to the persistence of attitudes of careful and critical attention, rather than of actual emotional inhibition.

Postman and Bruner (1948) also investigated the effect on perception of frustration during the experimental situation. The observers in these experiments were required to read three-word sentences exposed tachistoscopically with very short exposures. The exposures were gradually increased at successive presentations until the threshold values were obtained at which the sentences could be read correctly. To an experimental group of observers a complex picture was presented with a succession of very short exposures and when they were unable to perceive the picture, they were reproached and ridiculed, until they grew excited and tense with effort. Their results in subsequent attempts to read sentences were compared with those of a control group who had been allowed adequate time to see the picture. The control group showed an improvement in sentence reading from the initial to the final test performance, but the experimental group showed none. Moreover, the latter became more reckless in guessing, producing words which had no resemblance to the correct ones—and a fair number of words suggesting aggression or escape. Postman and Bruner concluded that in a frustrating situation the perceptual processes tended to become disrupted, and to regress to a more primitive, less systematic and well-adapted condition.

The same type of disrupted and irrelevant behaviour was demonstrated in an experiment by Mackinnon described by Boring, Langfeld and Weld (1948, p. 130). Some observers were required to perform a task for which three different solutions were demanded, only two of which were possible. The task was to stand within a square laid out on the floor with sticks, and, without leaving it, to obtain a flower which was placed on a stand four feet outside the square. This could be done (1) by placing a chair which stood inside the square between the observer and the stand, and leaning on it; (2) by kneeling down and reaching out from the kneeling position. But the observers were able to find these solutions only when they perceived the field as reorganized; that is to say, the chair was brought within their range of attention and recognized as a possible tool.

The observers were then kept for hours trying to achieve a third solution which did not in fact exist. The increased tension produced by their frustrated endeavours was expressed not only in anger, but also by many attempts at reorganizing the field, in which surroundings were regarded as barriers or possible tools. Some rings which had been left lying about were taken up and vainly juggled with. The fact that the back of the square had been made with two sticks instead of one was also noted, as if this might have had something to do with the solution. Indeed, behaviour of this kind seems fairly characteristic of the attempts to solve difficult problems. Numerous objects and features in the field are brought within the range of awareness that might previously have been ignored. Many possible 'meanings' or functions are attributed to them in accordance with the needs of the moment, and quite regardless of their actual utility. The greater the degree of frustration and of tension, the less relevant the nature of the perception, and the more disrupted the subsequent behaviour.

Further work on the operation of 'autistic' tendencies was carried out by Proshansky and Murphy (1942) and by Schafer and Murphy (1943), on the effects on perception of reward and punishment. Proshansky and Murphy presented their observers with series of lines of different lengths and of weights of differing amounts. In a preliminary and a final test, the observers had to estimate the length of the lines and the weight of the weights. In an intervening training period, they made no overt estimations of length and weight. But whenever the longest lines and the heaviest weights were presented, the observers were rewarded with money; and whenever the shortest lines and the lightest weights were presented, the observers were 'punished' by forfeiting some of the money already given. The estimates of the final test showed a significant increase, for both length and weight, over those of the preliminary test. Yet Proshansky and Murphy assured themselves that no conscious association had been formed between degree of length and weight, and reward or punishment.

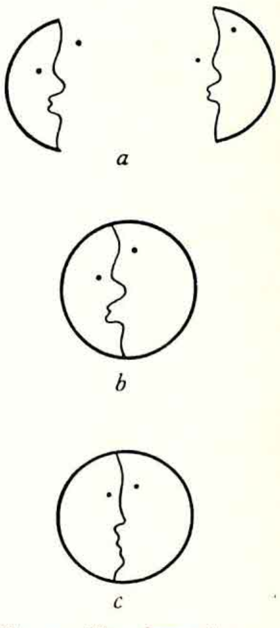

Fig. 30. The alternating profile figure.

In the experiment of Schafer and Murphy (1943), two ambiguous contours were used (see Fig. 30), which could be seen as one or other of two alternative profiles. In the training period, each of four possible profiles (see example, Fig. 30 *a*) was presented twenty-five times, for one-third of a second each, and a name was attached to each one. Two of these were 'rewarded' by giving the observer money on each occasion that they appeared; the other two were 'punished' by taking money away from him on most of the occasions on which they appeared. In the final test series, each of the two pairs of ambiguous figures (see Fig. 30 *b*) was presented sixteen times, together with certain other new figures containing only a single profile (see Fig. 30 *c*). Eighty per cent of the ambiguous figures were given the name belonging to the 'rewarded' profile. Again, certain precautions were taken to see that the observers did not consciously choose the 'rewarded' aspects, or realize that the ambiguous figures contained two alternative profiles. It was considered that autistic tendencies were aroused to image the 'rewarded' aspects, and that these influenced subsequent perception of ambiguous figures. These ingenious experiments do suggest how the individual's inherent needs and wants may direct his perception at least of material the interpretation of which is not clearly apparent to him.

But Haggard and Rose (1944) claimed that such rewards and punishments mainly affected situations in which the observers were actively 'set' to obtain a particular result. Their observers were required to estimate the extent of the autokinetic movement. One group, the 'active', was instructed to reproduce the movement by drawing it, and another, the 'passive', by merely reporting if it occurred. And half of each group was told that the light would move on most occasions; half, that it would move on some occasions. A reward of five cents was given for 50 per cent of judgements of movement to the left; and a forfeiture of five cents was made for 50 per cent of judgements of movement to the right. The observers were not consciously aware of this relationship of reward and punishment. In general, the 'active' group and those given the 'most occasions' instruction saw more frequent and larger movements than did the other observers. Moreover, the former produced an increasing number of judgements of movement to the left as the experiment progressed; whereas the latter did not. Thus the percepts were most influenced when the observer was both 'set' and 'rewarded' in congruent directions.

These experiments, then, show us that in general, as we should expect, perception of a particular situation is improved by satisfaction, success, and reward; while it is retarded, made less accurate and efficient, as the result of lack of reward, frustration, or anxiety. There is comparatively little experimental evidence as to the specific determination of perception by particular individual interests, although the evidence from everyday experience is fairly conclusive

It is to be hoped that further data may be obtained as to the effects of interest-determined schemata in producing individual differences in perceiving.

(6) PERCEPTUAL 'TYPES'

Finally, we must study the evidence for the existence of characteristic styles or modes of perceiving which differ between different individuals. Some experimenters have considered that these differing modes are due to temporary 'sets', specific to the particular situation or even to the particular material perceived. Others have attributed them to the existence of perceptual 'types'; that is to say, it has been postulated that certain individuals perceive typically in certain ways in all perceptual situations, whereas others perceive typically in a different manner. These 'types' have sometimes been related to characteristic temperamental differences.

Some of the most frequently described tendencies to perceive in a certain way, usually attributed to 'attitudes', are the *synthetic* and *analytic*. The adoption of the synthetic attitude leads the observer to see the perceptual field as an integrated whole, without much regard for detail. The analytic observer on the other hand concentrates on isolated or unrelated detail, and does not see the pattern or configuration of the field as a whole. Grahmann (1930) found such kinds of attitude in individuals observing landscape pictures. But intermediate attitudes were possible when a certain amount of detail was seen as well as the whole. The adoption of a completely synthetic attitude is undesirable in psychophysical experiments where small details of one part of the field must be discriminated. Thus Jaensch and his co-workers found that individuals who habitually adopted a highly synthetic attitude (whom he called 'integrates') were often rejected as useless for psychophysical observations (cf. Oeser, 1930). But judging from the work of George (1917) described in Section (4), a completely analytic attitude may also be unfavourable, since it tends to favour the use of long-drawn-out secondary judgement processes rather than of immediate estimates. Certain illusions are also seen better when a synthetic rather than an analytic attitude is adopted. Benussi (1914b) found that with a synthetic attitude the Müller-Lyer illusion could be perceived in 82–100 σ, but with an analytic attitude a period of 1,000–1,600 σ was required. He also found that the adoption of the analytic attitude might preclude the perception of the apparent movement phenomenon. The size of the index of phenomenal regression seems to vary according to whether the observer adopts the analytic or 'sensory' attitude, or the synthetic or 'object' attitude. Both Grahmann and Benussi were of the opinion that observers belong normally to a synthetic or analytic type; though Grahmann allowed there to be an intermediate type also. He found that the number of the synthetic and intermediate types decreased with age from 96 per cent at ages nine to thirteen years, to 82 per cent after the twentieth year. Nahm (1932) again found that in the simultaneous and successive comparison of size of geometrical forms grouped in complexes, some observers always apprehended the complexes as simultaneously perceived unitary wholes; their judgements about specific shapes were purely inferential. Others attended successively to the specific elements of one complex, and then compared them with those of the other. Their judgements were thus fewer but more accurate.

Some fairly well established habit of response seems to be indicated by the results of Wohlwill (1933), who tested the comparison of brightnesses, touches, and loudnesses of sounds, with one of each pair of stimuli partially obscured or masked by flicker, fluctuating touch, or noise. The observers were instructed to adopt either (1) an analytic attitude, with the comparisons made with the greatest possible abstraction from the obscuring medium, or (2) a totalizing attitude, with the comparisons made under the influence of the obscuring medium. Some observers were most successful when they adopted the first attitude, others the second; while some could change easily from one to the other. But similar attitudes were spontaneously adopted by these individuals in other free and experimental situations. Schmidt-Durban (1939) also considered that there existed a 'plastic' type intermediate between the analytic and synthetic, and that the plastic was a later developed type, possessing a higher level of structure than did the other two.

A similar typology was postulated at an earlier date by Messmer (1904) in his studies of normal and tachistoscopic reading. He distinguished between the *objective* and *subjective* types. The former was said to be characterized by a rigid ocular fixation, narrow perceptual span, and objective accuracy of perception; also by the reading of words from their 'dominating' letters (that is, the outstanding letters, such as the ascending letters, b, d, l, etc. and the descending letters, g, p, y, etc.). The subjective type was characterized by a fluctuating fixation, broad perceptual span, and subjective interpretative tendencies; and by the reading of words from their total word form. Children were said to belong to the latter category. Wiegand (1908), however, repeating these experiments, found that the same individuals might show these two types of perception at different times, according as to whether their attention was concentrated on the fixation point, or spread over the whole field. But Angyal (1948) found that obsessional individuals showed extreme consistency and rigidity in their patterns of response to letters arranged round the circumference of a circle and exposed for half a second—that is to say, they always began to read at the same point, and went the same way round the circle or grouped the letters in the same way, and they were extremely accurate in their reports. Anxiety and hysteric cases, on the other hand, showed a low consistency of procedure, with low accuracy and great variability in the number of letters reported. These two opposing types do seem to demonstrate their temperamental differences in their mode of tachistoscopic reading.

A similar differentiation in the mode of perception seems to arise even in children, although possibly in relation to age and to educational background. Thus Smith (1914) found that in the tachistoscopic perception of pictures, some children adopted an *active* attitude and analysed out the details of the picture; they seemed to correspond to Messmer's objective type. Others adopted a *passive* attitude, seeing the picture as a whole. This latter attitude was accompanied by marked subjective tendencies in interpretation; that is to say, the invention of features not actually present in the picture. In the main, six-year-old Primary School children were passive in type; in so far as they were at all active, it was to invent inaccurate and irrelevant details. At twelve years, however, the more intelligent of these children had advanced considerably in objective accuracy. Even then, they were inferior to twelve-year-old boys from a Grammar School, who showed much objective accuracy and mental activity in analysing the pictures and inferring relevant details. Smith concluded that educational and social background played an important part in the determination of perceptual ability. Segers (1926), on the other hand, considered that the objective type was more common among children from six to eleven years of age, while the subjective type appeared at nine years and increased from then onwards. In the results of Osterreith (1945), described on p. 35, it seemed that children of seven to eight perceived the specific detail of a complex diagram accurately, but did not perceive the general structure at all accurately until ten years or upward. It appears from these results and from those of Piaget (1937) that in general objectivity or subjectivity in a child's perception of a particular situation is related to the manner in which that situation affects him, and that this varies with age, and no doubt with other factors such as interest.

A rather similar difference in adults was found by Hanfmann (1940) in the performance of the Vigotsky test. These adults, who were of good intelligence, could be divided into those (in general the better educated) who worked at the test mainly in a rational way, constructing hypotheses as to the correct solution in their minds; and those who worked mainly by immediate perception of the salient characteristics of the pieces in the test, and made trial-and-error combinations of these characteristics. There were also some individuals who oscillated between the two procedures, and experienced considerable confusion in consequence.

It is possible that these different modes of perceiving may be partly a function of maturity, partly of social and educational background; but may also have some temperamental basis. This seems to be true of the modes described by Bartlett (1932) as the attitudes of *confidence* and *caution*. The confident observer attempted to report all that he saw of a complex presentation at a single glance; in his hurry he seemed to see more than was actually given, thus reporting, with disconnected material, more details than were actually present. The cautious, hesitating observer, afraid to give a wrong report, described less detail than was actually present.

An attitude similar to these is the critical or *evaluative*. Bartlett found that this frequently occurred with pictorial material. Whether the adoption of this attitude resulted in satisfaction and pleasure, or dissatisfaction and displeasure, depended partly on the stimulus material, and partly on the observer's interests and preconceptions. That is to say, it was in part determined by the observer's general characteristic attitude to a perceptual situation such as this; and in part by certain special features of the particular experimental situation. Bartlett found that this attitude was connected with the ease with which meaning was derived from the figure, and with the nature of the meaning attached. Anderson (1930) found that two types of evaluative attitude could occur, as we discussed on p. 222—the personal valuation of the stimulus object as pleasant or unpleasant, and the impersonal valuation in terms of some conventional standard, of beauty, ugliness, etc. The second type of valuation occurred more readily with the more complex stimuli, especially those of a situational kind; for instance, when the suitability and symmetry of colours and the harmoniousness and fittingness of tones were judged. Bartlett also found that frequently upon such evaluative reactions was based the decision as to whether the interpretations of certain pictures or parts of them should be accepted or rejected; and thus the result of the perceptual act was to some extent determined by them. Cantril (1932) showed that these valuations were remarkably constant in nature. Thus the evaluative attitudes towards certain words were found to remain the same when the words were presented on successive occasions, although the associations aroused by the words might vary. But it seems likely that the tendency to evaluation, or the type of evaluation, whether personal or impersonal, might vary according to the general and prevailing attitude of the observer. One might expect the subjective or 'integrate' type of observer to be characterized by a tendency to subjective evaluation; the objective or 'disintegrate' by impersonal evaluation. It is even possible that such attitudes might be characteristic of the Jungian extraverted and introverted sensory types. But we have no evidence as to the behaviour in controlled experimental settings of the Jungian types. Also, Anderson (1930) showed that, although these attitudes constantly recurred, nevertheless they rarely persisted over any length of time. Impersonal valuation was less persistent than personal valuation. It seems possible that the former is greatly reinforced and promoted by special training.

Of late years, there has been a decline in the popularity of ascribing differences in mode of perceiving to inherent typological differences of a temperamental nature.[1] Perhaps this has been due to the eclipse of some of the German typological schools. It is also true that as further experimental data have been obtained, it has proved more difficult to allocate observers to one or other of two contrasted types. One typology, of a rather different nature, has however been advanced comparatively recently: the *visual* and *haptic* typology of Lowenfeld (1945). These types characterize those individuals, mainly children, who perceive relatively much more easily by vision, and those who perceive relatively well by touch and kinaesthesis. Many blind children rather naturally fall into the latter class. But the main difference between these two types lies in their ability to use visual, or kinaesthetic and tactile imagery. Thus this typology resurrects the earlier very popular subject of the differing imaginal types, for the existence of which there is much evidence. There seems very little doubt that in certain individuals imagery of one modality is relatively clearer and more vivid than imagery of other modalities. But no one except Lowenfeld seems to have followed up the relationship of preferred imagery to manner of perceiving.

As the popularity of typology has waned, the use of factorial analysis has spread. We mentioned on p. 79 the investigation of Thurstone (1944), who administered forty different perceptual tests and experiments to 170 students, inter-correlated their numerical scores, and submitted the correlations to factorial analysis. The tests included: tendency to see certain visual illusions; alternating perspective and retinal rivalry; Gestalt 'closure' of various figures; apparent movement, flicker, and 'constancy'; hidden pictures and shapes, mutilated words, the Street completion test, Kohs Blocks; reaction time, perception time, and visual-motor co-ordination; and certain tests of reasoning and of other 'primary mental abilities' (see Thurstone, 1938). Eleven primary uncorrelated factors were obtained from the perceptual test results. One of the most important of these, which showed a high loading in tests of 'closure', (such as the constancies, perception of dotted figures, hidden shapes and words, Street completion, the Gottschaldt figures and Koh's Blocks) seemed to involve the ability to see configurations readily with considerable strength and speed of closure and ability to hold it against distraction. A second factor, which showed high loadings on the Gottschaldt figures, hidden pictures, two-hand co-ordination, and Kohs Blocks, was said to be connected with the ability to manipulate two configurations simultaneously or successively, and with flexibility in dealing with competing configurations. There also appeared factors of speed of perception; of speed of judgement in settling ambiguities; and of susceptibility to optical illusions. The second of the two principal factors was shown to correlate significantly with scores on a test of 'spatial' factor and one of word fluency. But it was not possible to calculate the correlation of the first perceptual factor with 'spatial' factor, since the former was a composite containing within it scores on the 'spatial' factor test. Again, it was not possible to calculate the correlation of the second perceptual factor with reasoning, since this factor was a composite containing within it scores on the reasoning test. Thus we cannot tell how far the flexibility in manipulation of configurations was a function of intelligence or reasoning ability.

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[1] But the most recent work on perception as a function of the total personality is reviving this approach. Thus Klein (see Blake and Ramsey, 1951, p. 328) describes the results of experiments demonstrating the influence on perception of three pairs of contrasted 'attitudes' which he considers to be inherent in the personality and closely linked with the ego-structure and its control system.

The first of these factors seemed to indicate a tendency to over-determination by perceptual wholes, with relative inability to analyse these into their constituent parts. Witkin (1949) has found that such a tendency, shown by difficulty in detecting simple figures 'embedded' in more complex ones, was associated with a tendency to rely upon the visual framework rather than the gravitational senses in his experiments on the perception of tilted fields (see p. 85). His observers showed fairly consistent tendencies to rely either upon the visual framework, or the gravitational senses, whether it was a part of the visual field, or the whole of it, or the body itself, which was tilted. Witkin states that those who made the 'gravitational' judgement were more able than were the others to separate their bodies from the visual field. He found that men tended to fall into this class; whereas children and women were more liable to adhere to the visual framework. In spite of the very considerable differences in their judgements of the vertical both classes of observer were satisfied that their judgements were the right and natural ones. From this Witkin deduced that they genuinely *perceived* the orientation of the vertical test object in terms either of the visual framework or of the gravitational senses, and did not merely work it out through a process of reasoning.

In some experiments of the author's (1947), rather different perceptual material was used; this included various meaningless geometrical shapes, pictures of jumbled objects, scales and dials, dotted and inverted letters, coloured and black-and-white pictures and silhouettes. It was found in the first place that the achievement of various individuals in perceiving the material varied not only with the type of material used, but also with the method of presentation, whether by very short exposure, or longer exposure, or by gradually increasing intensity of illumination. There was, however, some indication that those individuals with a low differential threshold for brightness were relatively good at perceiving and discriminating pure shape and pattern characteristics. But their results showed no correlation with scores on a test of 'spatial' ('*k*') factor; thus they were not especially skilled in the imaginal manipulation of perceived shapes. Other individuals, who also did well on non-verbal intelligence tests, showed ability in interpreting the perceived shapes in terms of the schemata appropriate to them—that is to say, as letters or numbers, scale readings, meaningful pictures, as the case might be. Thus the first type might be said to be rapidly aware of shape as such; the second, more skilled in making intelligent use of shapes, and not over-determined by particular shapes. There may be some correspondence between these two types of ability and Thurstone's two main perceptual factors, and with Witkin's 'visual' and 'gravitational' observers. It is harder to see any relationship between them and the analytic-synthetic or objective-subjective classification. Moreover, in experiments on the 'constancies' it appeared that it was the more intelligent and mature individuals, using the analytic attitude, who gave 'sensory' judgements, that is to say, judgements based upon sensory impression of shape as such. However, this may have been due to the fact that their judgements were not over-determined by configurational factors related to the nature of the 'real' object.

Thus we can conclude little more than that in some perceptual situations one or other of two main and contrasted types of procedure may be employed by the observers. But it is probable that the types of procedure vary according to the type of perceptual situation. We may have no assurance that similar contrasted types would occur in ordinary everyday life perceptual situations. It seems quite possible that the individual of moderate intelligence but with a low brightness threshold and high visual acuity might be relatively better at the differentiation of pure shape, and might be more subject to simple configurational 'closure'. Whereas the more mature and intelligent individual would be more able in the understanding and interpreting of complex situations, which he may do mainly by virtue of his superior intelligence. In simpler perceptual situations, it is likely that intelligence differences, within limits, play comparatively little part.

To sum up: It seems most probable that the individual carries with him into every perceptual situation, either in the laboratory or in normal life, his characteristic sensory abilities, intelligence, interests, and temperamental qualities. In so far as he may specifically relate any of these to that total perceptual situation, his responses will be coloured and to some extent determined by these inherent individual qualities. Thus his response may vary not only according to the nature of the qualities possessed, but also to the degree to which they become 'involved' in the perceptual situation. As Wolff

(1943) has pointed out, the degree of 'involvement' may vary considerably between one individual and another, and for the same individual in different situations.

In laboratory surroundings, as we have discussed above, the main motivational factor often appears to be a readiness to co-operate with the experimenter and do what he is felt or supposed to require. Thus individual differences in emotional and motivational factors will be of comparatively small importance except in so far as they affect this co-operative readiness. Instances of such an effect were given by Verville and Cameron (1946). In everyday life, again, different perceptual situations will be encountered with different degrees and types of involvement of the different inherent individual qualities. At present we can do little more than speculate as to what their effect may be upon the perceptual reactions.

CHAPTER XI

CONCLUSION

At the beginning of this book we stated that the percept does not mirror the exact stimulus conditions of the external world, nor is it completely determined by the sensations passing from the sense organs to the central nervous system. The truth of the statement has been amply demonstrated by the experimental data described in the book. We have seen that patterns of visual, tactile, and kinaesthetic sensations are perceived as solid objects having an enduring existence. These perceived objects exert an inclusive influence on their constituent parts, but appear sharply delimited and isolated from one another. And these two qualities of inclusiveness and delimitation appear also in representations of objects, and even in simple shapes, at least to adult observers.

Further, it was postulated that these qualities of the constituents of the external world were constructed from the primary sensory data in the course of the perceptual process, in order that the observer might preserve as far as possible the appearance of stability, persistence, and consistency of the environment; and hence be able to understand it, and know how to react to it satisfactorily. In doing this, it was essential for him to be able to differentiate between what was familiar, well-known, and enduring, and what was new, unexpected, in rapid change, potentially important, or harmful. Thus he set up for himself a numerous and complex arrangement of 'schemata'—ways of apprehending and reacting to particular classes of situation. These schemata, although possibly possessing some innate basis in instinctive needs or temperamental peculiarities, were developed largely during the course of the individual's life-time. Any perceptual situation encountered could then be fitted into its appropriate schema or chain of schemata, by virtue of the 'effort after meaning', until it was understood and reacted to in the most satisfying and effective manner.

We have described types of schematized reaction: to permanent and stationary objects, representations of objects and shapes; to changes of appearance of objects with change of position; to moving and inter-acting objects; to the position and movement of the body in relation to surrounding objects. But although certain very general outlines or typical responses have been indicated, there has appeared a bewildering multiplicity of variations—between different individuals, and for the same individual in only slightly different situations. Even the most carefully controlled experimental situations vary unpredictably in their effects upon the behaviour of different persons and at different times. Often the experimenter can recognize that each observer is going about his task in a different way, but is quite unable to understand or describe the differences. For the overt response of naming, description, reproduction, etc., is analogous to the visible part of an iceberg; submerged and out of sight are the innumerable unconscious and semi-conscious processes by which the individual reaches his overt response. Such similarities and generalizations as we have discovered may relate only to these overt responses; while the underlying processes are infinitely varied because the directing schemata are different in every individual.

It is possible that a more careful and systematic use of that uncertain instrument, introspection, will eventually bring more to light. Certainly it would be valuable to have more careful and detailed records of the observer's every reaction to the smallest modification of controlled situations. Furthermore, let these records be made as far as possible without bias, and not forced to conform to some preconceived theory. The time is too early for any exact theoretical explanation of the development and functioning of the schemata. Finally, the most hopeful line of approach may be through the study of these schemata as they actually develop in the young child. The child cannot produce verbal introspections into his mental processes. But he does demonstrate much more freely than the adult, by his spontaneous behaviour—and particularly by his 'mistakes'—how the categories of percept and reaction are integrated and schematized. The work of Piaget in particular has given an indication of the manner in which these studies can be made. But many of Piaget's conclusions are based upon insufficiently controlled observations. Careful and detailed observation is necessary of the spontaneous behaviour of a larger number of children; and this behaviour studied, not as a mosaic of discrete items, but in its continually developing patterns of understanding of the world.

APPENDIX A

Since this book went to press, there has appeared a new publication by Gibson (1950), much of which is extremely opposite to the arguments presented above. It seemed therefore to be most desirable to include in this book some discussion of Gibson's work. Gibson's main thesis is advanced as a contradiction, or at least a correction, of the theory that our perceptions are individual schematized constructions based only in part upon data given by the retinal impressions. He considers that in fact the perceptions of different observers are far more alike than such a theory would lead one to suppose, and also they reflect more accurately the nature of the external world. Thus he emphasizes the likeness, the consistency, and the accuracy of our percepts, rather than their imperfections, their inconsistencies, and their individual differences, which he conceives to originate largely in the artificially simplified conditions of laboratory experiments on perception.

Gibson postulates that the retinal impression, though not a photographic 'picture' of the external world, nevertheless is closely correlated to the variations in light stimuli arising from the external world. The retinal impression in turn is closely correlated to the momentary percept of a single stationary eye. This Gibson calls the 'visual field', which is an extent, bounded by the limits of clear vision, filled with flat patches of different shapes, colours, and sizes, clearly discriminable from one another. It shows abrupt transitions which we see as edges or contours, and a regular patterning which we see as surface texture. But we become aware of the 'visual field' only by introspective analysis from our total long-term experience, which Gibson calls the 'visual world'. This consists of solid stable objects localized in an unbounded or panoramic space. It is built up through the integration of innumerable overlapping adjacent and successive momentary percepts, obtained in successive ocular fixations. These percepts resemble one another in certain respects while differing in others. Since there is continual movement of the eyes and head in viewing the external world, there is continual transposition of stimulation on the retina. But this seems to be compensated directly, possibly through sensations of eye movement, so that the external world in fact appears stationary. These successive impressions, varying from each other, but varying in a recognizable and orderly fashion, are fitted together to produce the experience of the 'visual world' of stable solid objects localized in space. Their localization, and hence our perception of distance, is based upon relationship to a regular serial order of surfaces (along the ground), graded from near to far in size, shape, surface texture, and degree of deformation produced when the body moves in space.

It seems clear from the data relating to perceptual development in children, and still more from those of Senden (1932) on post-operative cases of congenital blindness, that even if the impressions of the 'visual field' are innate and unlearned, the total impression of the 'visual world' must be gradually built up in the light of experience. But Gibson wishes to minimize the importance in this building up both of individually constituted schematized meaning, on the one hand; and also of the Gestalt Laws of innate spontaneous organization, on the other hand. The former would posit too much individual difference between the percepts of different observers. The latter are operative only in artificially simplified situations where perception is of simple two-dimensional shapes, often ambiguous in form, which are no more than projections of real objects in depth.

The author is in full agreement with much of Gibson's argument, but is unable to see the force of all his criticism. Granted that the retinal impressions are accurately correlated with the stimulations arising from the external world, and that this world is much the same for different individuals, who moreover possess similar sensory and nervous systems, there seems no reason why the 'visual world' which is built up from the momentary impressions should not also be broadly similar for different individuals. No one would deny that, in a general way and over a long period of time, experiences of shape, size, colour, distance, movement, etc. are much the same for everyone. They are also reasonably accurate whenever we can check their accuracy. But certain inaccuracies, such as those of the visual illusions, affect everyone. We *do* misjudge distances, even in critical situations; hence the frequency of road accidents. And individual differences do occur when careful and analytical discrimination is required, since usually different individuals have had different amounts and types of training and experience in making such analyses. They also have had different experiences in the schematic categorization of perceptual data, and hence they attribute different amounts and types of meaning to them. Thus in broad outline and for the immediately practical purpose of getting about, the 'visual world' may be equally well perceived by all of us; in detail, and especially in the particular detail to which we choose to attend, it certainly is not. It may be true that psychologists have devoted too much study to small differences and imperfections, and too little to the broad outlines of everyday experience. But it is difficult to control and analyse perceptions of the 'visual world' without breaking them up into perceptions of the 'visual field' which we are then unable to re-integrate.

APPENDIX B

As instances of the extreme differences which may exist between individuals in perception of rather complex material exposed only for a short period of time, we may quote the following reports given by five intelligent and educated adults on seeing for about two seconds a reproduction of a picture by Walter Sickert, 'Brighton Pierrots'.

1. 'A picture by a late nineteenth-century artist, the sort of thing one sees in the Leicester Galleries. A man standing in a straw hat, with nineteenth-century clothes, on an open space in front of a building, looking down. There were buildings at the back with a kind of portico, as if one were standing on the top of the steps of St Martin's-in-the-Fields. Possibly a picture by Sickert.'

2. 'A Cézanne, I think. A Spanish piazza with some sort of elevated platform on the left in the foreground. One male figure with a sombrero.'

3. 'A reproduction of a stage scene. Costume looked Elizabethan—at least, that of the man standing on the front of the stage did. An open-air theatre. An observer to the left of the stage looking across it; the audience on the right and in the background. In the foreground of the stage a figure of a man, and in the central background a girl in a much more modern dress like a country girl's, Victorian, pinkish-white in colour, with a full skirt and bodice. She seemed to be disappearing hurriedly at the back of the stage, looking backwards, as if escaping or trying to avoid notice.'

4. 'Might have been a platform, with a wooden post in the middle, going up to the top. On the right, a very tall figure in blue, who might have been wearing a blue cocked hat. Behind him there were houses. On the left there was a wall or a platform covered over, and a woman in white sitting. There was a general impression of a crowd of people about. It might have been an execution; possibly some kind of mediaeval picture or a historic scene.'

5. 'Rather a hazy picture of rather a thin wood on the left, and I think houses on the right. A man in mediaeval clothes or armour standing at the edge of the wood looking towards the buildings. I think there was a lady behind him in the wood.'

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